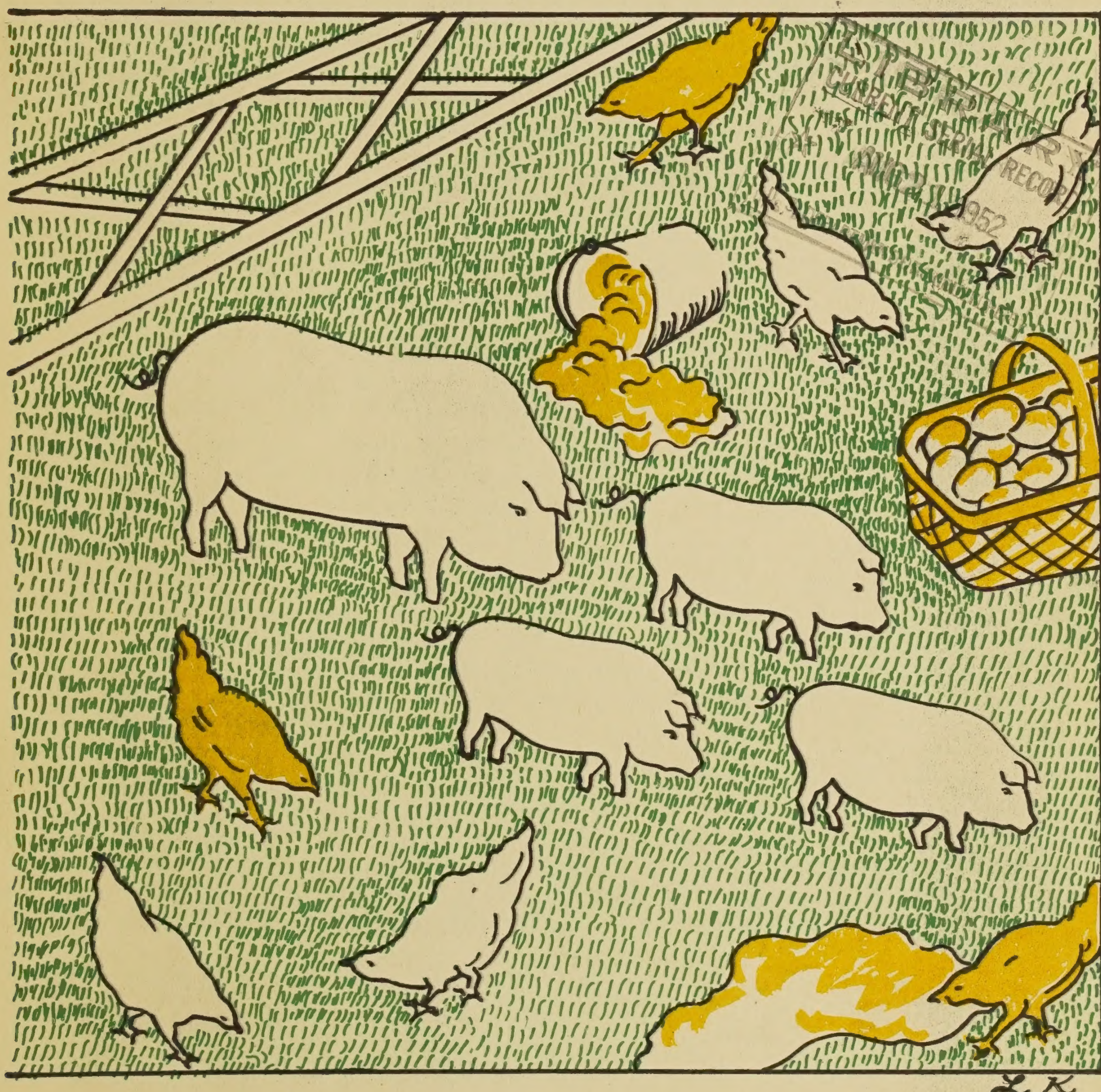
proceedings

2nd CONFERENCE ON COTTONSEED PROCESSING AS RELATED TO THE NUTRITIVE VALUE OF THE MEAL

NOVEMBER 5, 6, AND 7, 1951.
SOUTHERN REGIONAL RESEARCH LABORATORY
NEW ORLEANS, LA.



United States Department of Agriculture
Agricultural Research Administration
Bureau of Agricultural and Industrial Chemistry

FOREWORD

In this report, in summary form, is the information presented at the 2nd annual conference on processing as related to the nutritive value of cottonseed meal, sponsored jointly by the Educational Service, National Cottonseed Products Association, and by the U. S. Department of Agriculture. The conference was held at the Southern Regional Research Laboratory, of the Bureau of Agricultural and Industrial Chemistry, New Orleans, Louisiana, on November 5-7, 1951.

The objectives of this conference were:

To review available information on the effects of processing conditions on the quality of cottonseed meal and oil;

To take stock of what is known about the nutritive value of cottonseed meal and discuss the latest information on its use in feeding farm animals;

To note future research required to further the understanding of cottonseed meal nutrition and to develop new or improved methods of producing both meal and oil of the highest possible quality.

Much of the data presented are still preliminary, and it is evident that a great deal more study is needed before either processors or nutritionists can make definite recommendations for feeding cottonseed meals interchangeably with other protein feeds in the diets of swine and poultry. Nevertheless, it is clear from the reports that much progress has been made.

More detailed information on any subjects herein may be obtained from the author or organization concerned, and <u>no material from these Proceedings should be reproduced, or used in any way, without specific permission. The Proceedings, not a publication in the usual sense, were prepared primarily for the benefit of those in attendance at the conference, and hence are not available for general distribution.</u>

***

C O N T E N T S

Page

Opening Remarks --

C. H. Fisher 5

Reports on Feeding Experiments

The Nutritional Value of Screw-Pressed Cottonseed Meal When Fed as the Principal Protein Supplement for Farm Animals --
E. L. Stephenson 7

Response of Growing Animals Receiving Diets Containing Cottonseed Meal Prepared by Various Processes --
F. H. Smith 10

Amino Acid Supplementation of Cottonseed Meal Rations for Weanling Pigs --
H. D. Wallace 14

A Comparison of Cottonseed Meal and Soybean Oil Meal in Practical Broiler Rations --
Francis H. Bird 16

The Use of Pre-Pressed Solvent Extracted Cottonseed Meal as a Protein Supplement for Growing Pigs --
J. L. Fletcher 18

Buckeye Degossypolized Cottonseed Meal --
Kenneth Kuiken 20

Various Types of Cottonseed Meals in Rations for Chicks and Laying Hens --
C. L. Morgan 22

Pig Feeding Tests with Special Process Cottonseed Meals --
C. M. Lyman 25

Nutritive Value of Cottonseed Meal for Chicks --
J. R. Couch 27

Evaluations of Nutritive Value of Cottonseed Meals as Swine Feeds--
N. R. Ellis 30

Experiments on Gossypol in Diets for Chickens, and on Pink Discolorations in Eggs Caused by Some Component of Cottonseed --
Burt W. Heywang, Animal Industry, USDA 31

CONTENTS (Continued)

Page

Comparison of In Vitro and In Vivo Methods of Protein Evaluation--
Madelyn Womack 34

Round Table Discussions of Significant Questions in Nutrition

What are the limits of free gossypol content that affect the value of cottonseed meal in hog and chick feeds?
Discussion Leader: J. R. Couch 38

What are the limits of free gossypol content that affect the use of cottonseed meal in mashes for laying hens?
Discussion Leader: Francis Bird 51

What is the effect of processing conditions on the protein value for hogs, chicks, and cattle of meals containing .03% or less free gossypol?
Discussion Leader: N. R. Ellis 55

What is the effect of supplementing cottonseed meal with amino acids? How do mixtures of cottonseed and soybean meals compare to either used alone?
Introduction: N. W. Flodin 58
Discussion Leader: A. B. Watts 58

What is the relationship, if any, between the chemical properties, and the nutritive value of cottonseed meals?
Discussion Leader: C. M. Lyman 63

Reports on Processing and Related Research

Gossypol and Thiamine Material Balances in Commercial Processing of C/S
T. H. Hopper 66

Production of Screw Press Meals of Superior Nutritive Value in Commercial Oil Mills --
H. L. E. Vix and F. H. Thurber 70

Effect of Conditions of Rolling on the Chemical Properties of Hydraulic Pressed Cottonseed Meal --
C. G. Reuther 74

Screw Pressing of Cottonseed
A. Cecil Wamble 77

CONTENTS (Continued)

Page

Effect of Processing Conditions on the Color of Cottonseed Oil --
Catherine H. Pominski 80

Fundamentals of Production of Cottonseed Meals of Superior Nutritive Value --
A. M. Altschul 82

Immediate Processing and Engineering Problems Requiring Investigation --
E. A. Gastrock 87

Concluding Remarks
A. L. Ward 92

***

Appendix

Program 94
List of Attendance 97
Summary 100
Recommendations of the Standard Basal Rations Committee for Cottonseed Meal Experiments 101
Table 1. Analysis of Experimental Cottonseed Meals 105
Table 2. Distribution of Experimental Meals 106
Table 3. Description of Cottonseed Meals in Nutrition Processing Test 107

OPENING REMARKS

by
C. H. Fisher, Director
Southern Regional Research Laboratory

Members of the Conference, friends:

Before the conference proper gets under way, I should like to take a few minutes of your time to say for the Southern Laboratory and myself, that we are happy to have you with us. We consider it a privilege to serve as host to this second conference on cottonseed processing, where much valuable information on cottonseed meal and related subjects will be exchanged.

The entire effort now being expended to provide improved cottonseed meal on a commercial scale is enormous. Many organizations and individuals are engaged in this effort. I think that all of us have been impressed by the magnitude of the project and the number of men working on it, the importance and value of the objectives, the teamwork and the splendid spirit of cooperation being displayed by all members of the team.

This cooperation is active also in the Southern Laboratory. Dr. Altschul and his Protein and Carbohydrate Division have played a leading role from the beginning. The Engineering and Development Division, led by Mr. Gastrock, is helping to an ever increasing extent -- this Division is now giving a major part of its time to studies that should help develop improved processing methods and improved meals. The Analytical and Physical Division, headed by Mr. Hopper, has been active in cottonseed processing studies all along, they have made and are continuing to make notable contributions. When it comes to oil problems, we receive valuable advice and help from Dr. Markley and his Oil and Oilseed Division. Knowing that any organization must work cooperatively if it is to do its best job, I find it highly pleasing to watch different divisions of the Laboratory cooperate so effectively with each other -- and with other organizations -- in getting an important job done.

I should like to thank Mr. Ward, Director of the Educational Service, National Cottonseed Products Association, for his continued help and support; the many industrial, state and federal organizations for cooperation; and the many members of the Southern Laboratory staff who helped in arranging this conference. I know it is going to be a good one!

REPORTS ON FEEDING EXPERIMENTS

THE NUTRITIONAL VALUE OF SCREW-PRESSED COTTONSEED MEAL WHEN FED AS THE PRINCIPAL PROTEIN SUPPLEMENT FOR FARM ANIMALS

by
E. L. Stephenson
University of Arkansas

In experiments conducted at the Arkansas Agricultural Experiment Station, experimentally processed screw-pressed cottonseed meal has been fed to growing pigs. These experiments have shown this meal to be non-toxic even when fed at levels as great as 43%. Maximum pig growth was obtained by supplementing a 43% screw-pressed cottonseed meal basal diet with 6% of fish meal. When the cottonseed meal basal diet was supplemented with 0.3% lysine and 0.25% of an aureomycin and vitamin B_{12} concentrate, the resulting growth response was significant at the 0.05% level, but the response was not as great as that obtained by adding 6% of fish meal.

Additional study indicates that the greater growth response obtained by feeding fish meal was due to its content of an unidentified nutrient or nutrients. Recent research indicates that this factor is vitamin-like in nature and required in very small amounts.

Screw-pressed cottonseed meal has also been fed to laying hens. The objective of this study was to determine its effect on egg storage quality. The result indicates that levels as great as 20% may be fed without producing undesirable yolk or albumin color in the stored eggs.

One feeding trial was conducted to compare the nutritive value of hydraulic-processed cottonseed meal, screw-pressed cottonseed meal, soybean oil meal, and linseed oil meal as a protein supplement for fattening lambs. While more work needs to be done on this subject, the present data indicate that the screw-pressed cottonseed meal was slightly inferior to the other products. The differences between the screw-pressed cottonseed meal and the hydraulic cottonseed meal approached significance to the 0.05% level.

***

Discussion

Question: What was the storage time of the eggs you mentioned?

Answer: It was 6 months, at 38° F.

Question: What was gossypol content of the meal fed these hens?

Answer: Analytical results indicate a gossypol content of 0.007%, but Dr. Altschul suggests that it is safer to say less than 0.01% gossypol.

Question: How many eggs were stored?

Answer: There was a total of over 100 eggs stored from the hens receiving each diet. Those from hens fed experimentally processed screw-press Meal No. 7, Series 1 (See Table 3 in the Appendix) were only slightly lower in grade than eggs from hens fed soybean oil meal.

Question: What was the level of cottonseed meal and of soybean oil meal in the feeds?

Answer: The cottonseed meal was at 20% level of the diet. The soybean oil meal was at 20% level of the diet.

Question: Did you ever boil any of the eggs and check their physical characteristics with those of the yolks before breaking? In our work, we have found that after boiling, the yolks frequently resemble art gum. This is noticed sometimes in our experiments with screw-pressed cottonseed meal as well as with hydraulic-pressed cottonseed meal.

Answer: We haven't boiled eggs, but the eggs obtained from screw-pressed cottonseed meal caused no difference in the flavor of baked products.

Question: Would you review your results with the lambs?

Answer: The lambs grew best on soybean oil meal, then on the hydraulic-pressed cottonseed meal, then on screw-pressed cottonseed meal, and last on linseed meal. The gains on these meals were respectively: 42.5, 41.0, 30.5, and 26.0 pounds.

Question: Do you have the oil content of these meals?

Answer: The cottonseed and linseed meals had about 5% and the soybean meal 0.5%.

Question: Identify the screw-press meal used.

Answer: It was No. 12 of Series 5. (See Table 1 in the Appendix).

Question: What was composition of lamb diet?

Answer: Lamb ration was composed of starch, cerelose, protein supplements, corn bran, minerals and vitamin supplements.

<u>Question</u>: What was the concentration of the cottonseed meal in these diets?

<u>Answer</u>: Believe 18%, but would have to calculate.

<u>Question</u>: On your experiments with pigs, how long was the feeding carried out?

<u>Answer</u>: The experiments were carried out until the pigs reached 100 lbs. These pigs were good growing animals (Duroc and Poland China) -- some of the fastest animals we've had. Some gained from 40 to 100 lbs. in a very short time.

<u>Question</u>: What was the concentration of the cottonseed meal fed these pigs?

<u>Answer</u>: The cottonseed meal was fed at 43%. The meal is identified as S12-T4 (See Table 1 in the appendix).

<u>Question</u>: What lysine was used?

<u>Answer</u>: d l-lysine monohydrochloride.

<u>Question</u>: How were the fish soluble extracts prepared?

<u>Answer</u>: The extracts were prepared by mixing the fish solubles with 95% ethanol and filtering.

<u>Question</u>: Doesn't fish soluble contain B_{12} in large proportions?

<u>Answer</u>: Yes, but we had already added B_{12} and aureomycin in the recommended amounts.

<u>Question</u>: What was the B_{12} content of fish solubles?

<u>Answer</u>: Fish solubles vary in B_{12} content. It was possibly 15 micrograms B_{12}/gm. plus the added aureomycin.

***

RESPONSE OF GROWING ANIMALS RECEIVING DIETS CONTAINING COTTONSEED MEAL PREPARED BY VARIOUS PROCESSES

by
F. H. Smith
North Carolina Experiment Station

Isocaloric diets, prepared from (1) hydraulic, (2) solvent extracted and (3) "Degossypolized" cottonseed meals were fed to weanling rats. Gossypol was added to (1) to raise its content to 0.118%, the amount in (2). Cottonseed meal (3), 0.046% gossypol, was used in the control diet. The diets contained 10% protein from cottonseed meal, 10% fat, adequate vitamins and minerals and starch to give desired composition. Seven rats were individually fed each diet.

The difference in gain in body weight between (1) and (2) was significant at the 1% level, and the differences between (3) and (1) or (2) were highly significant.

The differences in gains between (1) and (2) cannot be ascribed to free gossypol. Neither can the differences between (2) and (3) be attributed to free gossypol unless very small amounts have marked effect. Excellent gains were obtained with (3). These results suggest that the protein quality has greater effect than gossypol content on the gains of the rats.

Response of Rats to Diets Containing 10%
Protein from Different Cottonseed Meals

Cottonseed Meal	Gossypol	Mean Gain	L.S.D.	L.S.D.
	%	gm.	5%	1%
Hydraulic	0.118	45.1	10.3	14.1
Solvent Extracted	0.118	59.3		
"Degossypolized"	0.046	81.4		

In a test with pigs, two pigs per pen, and three replications thereof, were fed similar diets to compare "Degossypolized" cottonseed meal with soybean as source of protein. After all pigs were fed a standard ration for three weeks preceding the experimental study, the average weight was 73 lbs. The protein level in the diet was reduced from 18 to 16% when pigs attained weights of approximately 75 lbs. and to 14% at 125 lbs. The diets contained either soybean oil meal or cottonseed meal plus either the known required B vitamins or 6% alfalfa meal. All diets contained yellow corn, minerals and 0.5 Lederle's A-P-F and vitamins A and D.

Results from Soybean Meal vs. "Degossypolized" (0.052% gossypol) Cottonseed Meal Trial with Pigs

Pigs	Soybean Meal + Vitamins	Soybean Meal + Alfalfa	Cottonseed Meal + Vitamins	Cottonseed Meal + Alfalfa
Final weight pounds	197	174	134	144
Daily gain average	2.21	1.78	1.13	1.25
Feed/100 lbs. gain	320	358	418	437

The growth response from the "Degossypolized" cottonseed meal was inferior to that from the soybean meal with either vitamins or alfalfa meal. Four pigs on cottonseed meal which had gained at the rate 0.71 lbs./day for 74 days gained 2.20 lbs./day when placed on the soybean diet. Two pigs developed dermatitis on the cottonseed meal diet, the more severe one being on the vitamin supplement, but recovered rapidly when changed to the soybean oil meal diet.

In another test with pigs, four diets varying in primary sources of protein were used, as follows:

(1) Soybean oil meal.
(2) Mixed supplement of soybean oil meal, 40%; fish meal, 20%; tankage, 20%; and cottonseed meal, 20%.

(3) Special-processed cottonseed meal (Southern Regional Research Laboratory).
(4) "Degossypolized" cottonseed meal.

The diets were essentially the same as previously described except "Aurofac" was used, and none of the diets contained alfalfa. Two pigs per pen, with three replications, were used in this study. The feeding period was from 12 to 16 weeks.

Performance Data in Pounds: Soybean Meal or Mixed Supplement vs. Cottonseed Meal for Pigs

Pigs	Soybean Meal (1)	Mixed Suppl. (2)	Cottonseed Meal Spec.Proc. (3)	Cottonseed Meal Degossy. (4)
Average initial weight	46.6	51.0	46.6	46.5
Average finishing weight	217.0	222.4	196.0	208.5
Average daily gain	1.83	1.85	1.39	1.54
Feed/100 lbs. gain	341	372	378	385
Percent gossypol			0.069	0.049

The differences between diets (1) and (2) are insignificant, but both are significantly superior to (3) and (4). Daily gains for (4) were higher than for (3), but the efficiency was lower.

Experiments also have been conducted in the feeding of cottonseed meal in starter rations to determine the maximum at which it can be fed to young calves.

Diets 2a and 2b were prepared from (1) special processed cottonseed meal 41%, gossypol content 0.059% (Southern Regional Research Laboratory), and 3a and 3b from (2) hydraulic cottonseed meal 41%, gossypol content 0.173% (Swift and Company). Diets 2a and 3a contained 60% and diets 2b and 3b 40% cottonseed meal with the latter two having 15% soybean meal in addition, thus giving the diets a crude protein content ranging between 28.3 and 29.5%. They were individually fed ad libitum.

Jersey (1 replication) and Holstein (3 replications) calves removed from the dam at 2 to 3 days of age received whole milk fortified with vitamin A and D to 35 days of age. They began to receive the experimental diets at 10 to 15 days of age and were consuming about one or more pounds of starter and about two pounds of alfalfa hay at weaning. Four calves received each diet and made normal gains although their coats were rough. The most thrifty animals were the ones lost. The calves went off feed about one week before death. Seven out of sixteen were lost between 49 and 120 days of age. Two deaths occurred on 2a, none on 2b, three on 3a, and two on 3b.

The animals appeared in pain and had labored breathing before death. Posting showed the blood to be incompletely coagulated and bright red in color. There was a straw-colored fluid in the abdominal cavity, ranging from two quarts to two gallons. Suggillation occurred in the heart valves in three and hepatization in the liver of one of the animals.

Calves: Cottonseed Meal in Calf Starters

Cottonseed Meal Process	Diet	Ingredients: Cottonseed Meal	Soybean Meal	Grain	Deaths
		%	%	%	
Special Expeller	2a	60.0	- -	37	2
(Gossy. 0.059%)	2b	40.0	15	42	0
Hydraulic	3a	60	- -	37	3
(Gossy. 0.173%)	3b	40	15	42	2

Mineral: Bone meal 2%, Salt 1%

***

Discussion

Question: In the trials with rats, how was gossypol added to the hydraulic-meal diet?

Answer: In crystalline form. The pure gossypol was ground in a mortar with starch to obtain a uniform mixture, then incorporated with the other ingredients of the diet.

Question: Were the mixes analyzed?

Answer: No. We did not analyze the ration after mixing the gossypol with the other components of the diet.

Question: How long was pure gossypol mixed with the diets before feeding?

Answer: It was mixed with the diets immediately before the feeding experiments began, and the rations were fed for 24 days.

Question: What solvent was used in processing the solvent-extracted meal for these diets?

Answer: I do not know, the material was supplied by the Buckeye Mill in Memphis.

Question: Was the "Degossypolized meal" also a solvent meal?

Answer: Yes, then treated with an organic amine (See report of Kenneth Kuiken, Buckeye Cotton Oil Co.).

Question: Were vitamins or antibiotics included in the diets fed the pigs in your experiments?

Answer: Yes, we had Lederle's APF at the 0.5% level for the antibiotic in trial I and 0.5% aurofac in trial II.

Question: What vitamins?

Answer: Vitamins A and D and all the known required B vitamins.

Question: Did you include fish solubles?

Answer: No fish solubles were added. The only other protein was from the corn and alfalfa in the diet.

Question: How many pigs were there per lot?

Answer: There were 2 pigs per pen, with 3 replications for each treatment.

Question: How much alfalfa was fed?

Answer: 6% in the diets of trial I, none in trial II.

Question: With the calves, how high did the consumption of feed go before death?

Answer: As high as 4 lbs./day.

Question: Were the diets fed as dry or wet?

Answer: They were fed dry.

***

AMINO ACID SUPPLEMENTATION OF COTTONSEED MEAL RATIONS FOR WEANLING PIGS

by
H. D. Wallace
Florida Agricultural Experiment Station

Eight groups of purebred Duroc weanling pigs were treated as follows:

Lot 1 - Corn + cottonseed meal
Lot 2 - Corn + cottonseed meal + 75 grams $CuSO_4$ per 100 lbs. of feed
Lot 3 - Corn + cottonseed meal + 0.4% dl-lysine
Lot 4 - Corn + cottonseed meal + 0.8% dl-lysine
Lot 5 - Corn + cottonseed meal + 0.4% dl-lysine + .075% dl-methionine
Lot 6 - Corn + 1/2 cottonseed meal and 1/2 soybean meal
Lot 7 - Same as Lot 6 + 0.4% dl-lysine
Lot 8 - Same as Lot 6 + 0.4% dl-lysine + .075% dl-methionine

The cottonseed meal fed in all lots was an experimental product from the U. S. Southern Laboratory S. 13 - T4. This meal contained 0.03% of free gossypol. All rations contained, in addition to the supplements described above, 5% of alfalfa leaf meal, 0.5% of Aurofac (aureomycin plus B_{12}), 45 grams of Lederle Fortafeed per 100 lbs. of feed, and adequate minerals. The crude protein content of all rations was approximately 19%.

Results of this experiment are summarized in the following table:

Results with Weanling Pigs Fed Various Diets .

Lot Number	1	2	3	4	5	6	7	8
Number of pigs	6	3*	6	6	6	6	6	6
Days on feed	67	67	67	67	67	67	67	67
Avg. initial wt.	34.4	35.6	34.4	34.6	34.6	34.4	34.4	34.3
Avg. final wt.	92.6	64.0	88.0	103.4	85.4	118.8	122.0	117.0
Avg. daily gain	0.87	0.44	0.80	1.03	0.76	1.26	1.30	1.21
Avg. daily feed consumption	3.59	-	3.41	3.68	3.21	4.39	4.48	4.32
Feed per 100 lbs. gain	413	-	428	359	423	349	342	350

*Three pigs died of Cu poisoning.

Pigs in lot 1 made gains of 0.87 lb. per day. The addition of 0.4% lysine (lot 3) did not increase gains. However, when 0.8% lysine was added a significant response was registered. A combination of the low level of lysine and methionine did not improve growth. When soybean meal replaced one-half of the cottonseed meal (lots 6, 7, and 8) gains were significantly increased. Amino acid supplementation (lots 7 and 8) was ineffective.

In last year's (1950) studies it was reported that a fading of the haircoat occurred in several lots. Copper sulfate was added to the ration of lot 2 to see if it would prevent this. Three pigs died of Cu poisoning but haircoats of the remaining pigs faded, as they did in all other lots except those receiving soybean meal. A dermatitis was also evident on one or two pigs in each of the first five lots.

At the conclusion of the trial twelve pigs which showed marked haircoat fading were divided into three groups and fed a corn-cottonseed meal ration with the following supplementations:

Lot 1 - 2% dl-lysine
Lot 2 - 20 grams $CuSO_4$ per 100 lbs.
Lot 3 - 3% Aurofac

A patch of hair was clipped from the side of each pig. In all cases the new growth following these treatments remained faded, showing no change as a result of these supplements.

***

Discussion

Question: Wasn't aureomycin fed at a higher level in your earlier experiments?

Answer: Yes, 3% Lederle APF No. 5 was fed in last year's trial which is an exceptionally high level. In this year's study 0.5% Lederle Aurofac was added to all rations. This is a fairly generous addition of the antibiotic.

Question: Were any of these pigs kept on a cottonseed diet beyond the feeding experiments?

Answer: Two gilts were carried through the breeding cycle and on farrowing had litters of 6 and 8 pigs. Two in each litter were light in color but outgrew this discoloration. However, they were not kept on a cottonseed meal diet beyond the date of farrow.

Question: Mention has been made of a dermatitis occurring in all lots except those receiving soybean meal. Were the pigs sprayed for mange?

Answer: Pigs used in this experiment were not sprayed for mange; however, the dermatitis syndrome was clearly not a mange. Nor could it have been caused from spraying since no spraying was done.

***

A COMPARISON OF COTTONSEED MEAL AND SOYBEAN OIL MEAL IN PRACTICAL BROILER RATIONS

by
F. H. Bird
Eastern States Farmers Exchange

Two studies have been completed which tested the ability of various process cottonseed meals to replace the soybean oil meal used in practical broiler rations.

The first study compared two cottonseed meal samples and one commercial solvent-extracted soybean oil meal. The cottonseed meals were processed by the hydraulic and screw methods with a free gossypol content of 0.108% and 0.011% respectively. These cottonseed meals on a protein equivalent basis replaced the solvent soybean oil meal in a

commercial-type of high efficiency broiler ration. Growth and feed efficiency data at 8 weeks of age were as follows:

Comparison of the Relative Effects of Cottonseed Meals and Soybean Meals on Growth and Feed Efficiency of Broilers

Type of Meal	Growth at 8 weeks Avg. Wt. (lbs.)	Avg. Wt. Gain (lbs.)	Avg. Feed Consumption (lbs.)	Feed Efficiency Feed/Wt.
Cottonseed Meal				
Hydraulic processed	1.83	1.74	4.55	2.49
Screw-pressed	1.86	1.77	4.52	2.43
Soybean Oil Meal				
Solvent extracted	1.89	1.80	4.38	2.32

The second study compared six cottonseed meal samples and one commercial solvent extracted soybean oil meal. The cottonseed meals represented 3 screw-press meals (2 experimental and 1 commercial), 1 butanone extraction, 1 isobutane extraction and 1 essentially gland-free meal. These samples contained respectively 0.012, 0.02, 0.02, 0.027, 0.36 and 0.06% free gossypol. They replaced solvent-extracted soybean oil meal in a practical-type high efficiency on a protein equivalent basis. Growth and feed efficiency data at 12 weeks of age were as follows:

Growth, Feed Consumption and Feed Efficiency of Chicks Fed Different Sources of Cottonseed Meal Compared with Chicks Fed Soybean Oil Meal

Type of Meal	Meal No.	Growth at 12 wks. Avg. Wt. (lbs.)	Avg. Gain (lbs.)	Avg. Feed Consumption (lbs.)	Efficiency Feed/Wt.
Screw-press C/S Meal					
Exp. Sample #1	S-5-13	3.63	3.54	11.18	3.08
Exp. Sample #2	S-5-16	3.60	3.51	11.44	3.18
Commercial Sample	S-6-3	3.67	3.58	11.42	3.11
Extracted C/S Meal					
Butanone Ext'n	S-6-10	3.68	3.59	11.29	3.07
Isobutane Ext'n	S-6-12	2.69	2.60	8.46	3.14
Gland-Free C/S Meal	26576	3.47	3.38	10.51	3.03
Solvent Soybean Oil Meal	E. S.	3.81	3.70	10.86	2.85

In this experiment four of the cottonseed meals (screw-press samples and the butanone sample) made good growth even though this growth response was not as great as that given by the soybean oil meal. Two of the cottonseed meal samples (isobutane extraction and the gland-free samples) gave unsatisfactory growth responses.

The soybean oil meal fed birds made the best efficiency of food utilization.

An abnormal beak condition was seen in a high proportion of the birds fed the isobutane-extracted and the gland-free meals. This condition, first noted at 6 weeks, became progressively worse as the experiment proceeded.

***

Discussion

Question: Were all the diets the same, except for the meal used?

Answer: The diets were approximately the same except for the fiber and fat content. The fat and fiber contents of cottonseed meal rations were higher than those containing soybean oil meal.

Question: How were the meals used in these studies prepared?

Answer: They are described on the Laboratory's Table. (See Table 1 in the Appendix).

Question: What was the protein content of your meals?

Answer: These also are on the Table. The experimental rations were adjusted to have the same total protein content.

***

THE USE OF PRE-PRESSED SOLVENT EXTRACTED COTTONSEED MEAL AS A PROTEIN SUPPLEMENT FOR GROWING PIGS

by
J. L. Fletcher
Mississippi State College

Five lots of seven pigs each were fed. Lot 1, which received a corn-tankage mixture, was considered the check. Lots 2 and 3 received a feed mixture containing corn and hydraulic processed cottonseed meal. In Lots 4 and 5, a pre-pressed solvent-extracted cottonseed meal was included in the mixture. For lots 3 and 5, one-half percent ferrous sulfate was added to the feed mixture. All five lots were self-fed. The free gossypol content of the hydraulic meal was 0.07% and of the pre-pressed meal 0.04%.

The results are summarized in the following table.

There were no evidences of gossypol toxicity in either of the lots receiving cottonseed meal. Although all cottonseed meal lots exceeded the check in gain, the differences were not significant.

COMPARISON OF COTTONSEED MEALS
February 29 to June 12, 1951

Lot	1	2	3	4	5
Ration*	Corn 82 Tankage 18 Salt 1/2	Corn 75 Hydraulic CSM 25 Salt 1/2 Oyster-shell 1	Ration 2 + 1/2 Ferrous Sulfate	Corn 75 Prepress CSM 25 Salt 1/2 Oyster-shell 1	Ration 4 + 1/2 Ferrous Sulfate
No. of pigs	7	7	7	7	7
Days on feed	105	105	105	105	105
Av.initial wt.	51.4	49.8	51.2	49.4	51.2
Av.final wt.	175.3	183.7	181.1	180.3	190.1
Av.gain	123.9	133.9	129.9	130.9	138.9
Av.daily gain	1.18	1.27	1.23	1.24	1.32
Feed per 100 lbs.gain					
Corn	349.9	328.1	379.5	327.9	354.9
Tankage	76.8	---	---	---	---
Cottonseed meal	---	109.4	126.5	109.2	118.3
Total	426.7	437.5	506.0	437.1	473.2

*All lots fed on small grain forage.

***

Discussion

None.

***

BUCKEYE DEGOSSYPOLIZED COTTONSEED MEAL

by
Kenneth Kuiken
The Buckeye Cotton Oil Company

The Buckeye Cotton Oil Company has introduced a product known as "degossypolized" solvent-extracted cottonseed meal. It is produced at Augusta, Georgia, and is available with protein contents of 36 and 41%. The product is guaranteed to contain not more than 0.04% free gossypol. The reduction in free gossypol content is accomplished by treating hexane-extracted flakes with an organic amine which combines with gossypol and renders it physiologically inert.

Buckeye "degossypolized" cottonseed meal is a mildly toasted product. The heat treatment, which is applied to remove the solvent after extraction of the oil, is analogous to that applied in processing soybeans to properly inactivate the anti-tryptic factors. Amino acid availability data indicate that heating under these conditions has a minor effect on protein quality in contrast with an appreciable reduction in quality as a result of cooking the protein in the presence of gossypol plus cottonseed oil.

The Buckeye Cotton Oil Company has made available to research groups large quantities of "degossypolized" cottonseed meal. It is anticipated that reports of feeding trials will appear on the program of this conference and in the scientific literature at an early date.

The work which has been completed in the Buckeye laboratories may be summarized briefly as follows:

Observations on toxicity or gossypol effects

No evidence of cottonseed toxicity has been observed in feeding tests with guinea pigs, swine, or chickens. Pigs have been fed a ration containing 45% degossypolized cottonseed meal, from weanling weight of 36 lbs. to a market weight of 185 lbs. with no ill effects. The average growth rate in this case was 1.5 lbs. per day.

An egg storage test resulted in approximately 30% off-color eggs, after six months storage, when the ration contained sufficient cottonseed meal to supply 0.003% free gossypol.

Swine growth studies

Good growth and feed economy have been obtained with pigs in dry lot trials with cottonseed meal as the only supplementary protein concentrate in the ration. The data shown in the following table were

obtained with a ration consisting of degossypolized cottonseed meal 34, yellow corn 59.5, fish solubles 3, salt mixture 3, A&D oil, riboflavin and calcium pantothenate. The need for the B-complex vitamins has not been demonstrated. Recent results of the U.S.D.A. indicate that addition of riboflavin probably is not necessary. The protein content of the ration was adjusted from an initial value of 20% to lower values as weight increased.

It is recommended that "degossypolized" cottonseed meal be used with equal parts of soybean meal, on a protein basis, for best results with pigs. Growth with the mixed protein and a properly supplemented grain mixture is frequently, but not always, better than that obtained on simple vegetable protein formulas. Fish solubles, which were used in this work to supply vitamin B_{12} and possible unknown factors, may have supplied sufficient supplemental lysine to improve growth performance.

Growth of Pigs on Rations Containing
"Degossypolized" Cottonseed Meal

Variable in ration	45% CS Meal	34% CS Meal	28% SB Meal
No. of pigs	4	4	4
Avg. initial wt., lbs.	35.8	35.8	34.8
Avg. final wt., lbs.	185.8	203.8	195.5
Days on test	98	98	98
Avg. daily gain, lbs.	1.53	1.71	1.64
Feed/100 lbs. gain	355	359	360

Chick Growth Studies

It is recommended that "degossypolized" cottonseed meal be used to replace not more than one-half of the soybean meal, on a protein basis, in a broiler ration. Small amounts of wheat and oats have usually improved performance when cottonseed-meal-containing rations were fed. Chicks in group 3, (see table below) received the following ration; corn 41, wheat 15, oats 5, soybean meal 10.5, "degossypolized" cottonseed meal 18.5, alfalfa meal 3, fish solubles 3, salt mixture 3.5, A & D oil, riboflavin and pantothenic acid. Growth rate and feed efficiency were very satisfactory even though the level of cottonseed meal exceeded the recommended level.

Chick Growth on Rations Containing
"Degossypolized" Cottonseed Meal

Variable in Ration	26% SB Meal	31% CS Meal	18.5% CS Meal 10.5% SB Meal
No. of chicks	33	24	33
Weight, 8 weeks	2.3	2.1	2.3
Lbs.feed/lb. gain	2.53	2.71	2.65

***

Discussion

Question: What was the free gossypol content of the meals you used?

Answer: 0.04% or lower.

***

VARIOUS TYPES OF COTTONSEED MEALS IN RATIONS FOR CHICKS AND LAYING HENS

by
C. L. Morgan
South Carolina Agricultural Experiment Station

Feeding trials have been conducted with chicks and laying hens in which screw press, solvent and hydraulic cottonseed meals have been used to entirely replace animal protein supplements and soybean oil meal in standard rations for chicks and laying hens. Two types of screw press meal were used in these trials. In the chick rations additions of the amino acids, lysine and methionine, singly and in combination, were made to one of these meals. Additions of lysine were also made to one of the screw-press-cottonseed-meal-supplemented laying rations. Similar rations using soybean oil meal as the protein supplement were used in comparison with the cottonseed-meal-supplemented rations. In one case screw press cottonseed meal was used to replace soybean oil meal in a chick ration containing animal protein. Vitamin B_{12} additions were made to all rations used in these trials.*

*The author is indebted to Merck and Company, Rahway, New Jersey, for the B_{12} supplement; E. I. duPont de Nemours and Company, New Brunswick, New Jersey, for the DL-Lysine monohydrochloride; and the Dow Chemical Company, Midland, Michigan, for the methionine used in these trials. Screw press meals were furnished through the Southern Regional Research Laboratory and the National Cottonseed Products Association. The solvent meal was furnished by the Buckeye Cotton Oil Company.

In the chick feeding trials on the basis of average weights of duplicate lots of twenty-five New Hampshire chicks at eight weeks of age, greater weights were obtained with the standard chick ration containing animal protein, the soybean oil meal supplemented ration and the ration in which screw press cottonseed meal replaced soybean oil meal in a ration containing animal protein. The weights of the chicks on rations in which solvent and screw press cottonseed meals entirely replaced the animal protein and soybean oil meal, chick weights were quite similar but nearly 15% less than the weight of the chicks on the check ration. The weights of the chicks on the check ration in which hydraulic cottonseed meal entirely replaced the animal protein supplements and soybean oil meal were approximately only one-half as great as the chicks on the check ration. The addition of 0.1% l-lysine to the screw-press cottonseed-meal-supplemented rations did not increase growth rate over the cottonseed meal alone. The addition of 0.075% methionine to the same ration was not effective. The addition of the same amount of l-lysine to a hydraulic meal ration increased chick growth only slightly but 0.4% l-lysine was quite effective.

With the solvent and the screw press cottonseed meals, there appeared to be some relation between soluble nitrogen and rate of growth of the chicks. With the hydraulic cottonseed meal, soluble nitrogen was apparently not a factor in the results. The total gossypol contents of all of the cottonseed meals were nearly the same. The hydraulic meal contained considerably more lipids than the other meals.

With laying hens the feeding trial was not of sufficient duration to accurately measure the effects of the various rations upon egg production. Studies on hatchability indicated satisfactory results with the solvent, hydraulic and one of the screw press cottonseed meals. With one of the screw press cottonseed meals somewhat reduced hatchability of eggs was observed. There was no relationship between soluble nitrogen content of the meals and hatchability.

Eggs stored for 30 days showed no harmful effects from the feeding of any of the types of cottonseed meal used in these feeding trials.

COTTONSEED MEAL IN BROILER RATIONS

25 New Hampshire Chicks (duplicate lots) 3/13/51-5/8/51 (8 wks.)

Protein Supplements*	Ave. Weight 8 wks.		Feed per lb.	
	Males	Females	of gain	Mortality
	Gms.	Gms.	lbs.	%
Check	844.0	764.5	2.30	0
CSM hydraulic	412.4	344.9	2.84	4
CSM solvent	720.4	619.8	2.39	0
CSM screw press S5-4	682.9	603.9	2.57	4
CSM screw press S5 Mixture of 9 & 10	753.3	674.4	2.76	2
SBOM (44%)	902.6	730.8	2.36	0
Check CSM S5 9 & 10 for SBOM	801.2	739.4	2.31	0
CSM S5 9 & 10 + 0.1% lysine	752.2	642.1	2.60	2
CSM S5 9 & 10 + 0.1% lysine and 0.075% methionine	700.2	666.2	2.74	8
CSM S5 9 & 10 + 0.075% methionine	651.7	604.1	2.74	4

*For a description of the meals see Table 1 in the Appendix.

***

Discussion

Question: Was the 0.1% lysine calculated as free lysine?

Answer: Yes--as free lysine, not lysine hydrochloride.

Question: What was the free gossypol content of the hydraulic meal?

Answer: 0.03 - 0.04%. The content of all these meals was about the same.

Question: Was the solvent meal detoxified?

Answer: Yes.

***

PIG FEEDING TESTS WITH SPECIAL-PROCESS COTTONSEED MEALS

by
Fred Hale and Carl M. Lyman*
Texas Agricultural Experiment Station

Four groups of 7 pigs each were fed individually on experimentally processed cottonseed meals furnished by the Southern Regional Research Laboratory. Lederle's aurofac (aureomycin with B_{12}) was added to all of the rations, except that used in Lot 4. The cottonseed meal fed to pigs in Lot 4 was the same kind of meal used in Lot 2. The rations are shown, and the results of these feeding tests summarized, in the following tables.

It is noted that pigs fed the meal T-3 used in Lot 2 gained 12% faster and required 23.7 lbs. less feed per 100 lbs. of gain than did the pigs fed the same cottonseed meal in Lot 4. Since the only difference in the ration was that the aureomycin with B_{12} was added to the ration in Lot 2, it is indicated that this difference in gain and in economy of gain is due to the aureomycin B_{12} product.

The pigs in all of the lots made very good daily gains and also economical gains considering the fact that the tests were run during the period of extreme hot weather. These results indicate that the ration in Lot 2, where the ration contained 19% cottonseed meal (with aurofac added), will give excellent results when fed to fattening pigs.

According to the results, the pigs in Lot 1 would have reached a 200 lb. average weight after 83 days on feed, the pigs in Lot 2 in 71 days, the pigs in Lot 3 in 84 days, and the pigs in Lot 4 in 80 days.

It is of particular interest to note that the cottonseed meal fed to Lot 2, which made the fastest and most economical gains, had the highest percentage of soluble protein. This cottonseed meal also had the highest content of thiamine.

---

*Presented by Dr. Lyman.

RATIONS USED IN COTTONSEED MEAL FEEDING TRIALS WITH FATTENING PIGS
July 12 - September 20, 1951

	Lot No.			
Ration in Pounds	1	2	3	4
Ground Milo	79	76	76	76
Cottonseed Meal	16 S12-T1*	19 S12-T3*	19 S13-T4*	19 S12-T3*
Alfalfa Leaf Meal	3	3	3	3
Limestone	1.5	1.5	1.5	1.5
Salt	0.5	0.5	0.5	0.5
Lederle's aurofac containing vitamin B_{12} and aureomycin	0.5	0.5	0.5	None

*Kind of cottonseed used (See Table 1 in the Appendix). Since the crude protein content of the T-1 meal was 45.19% as compared to 40.44% for T-3, and 40.50% for T-4, less cottonseed meal was needed per 100 lbs. of feed.

***

RESULTS OF FEEDING COTTONSEED MEAL TO FATTENING PIGS
Test began July 12, 1951 - Closed September 20, 1951 (70 days)
All pigs fed in individual pens

	Number showing type of screw-press CSM Feed			
	Lot 1 C-S-M No. S12-T1*	Lot 2 C-S-M No. S12-T3*	Lot 3 C-S-M No. S13-T4*	Lot 4*** C-S-M No. S12-T3*
Number of Pigs per Lot**	7	7	7	7
Avg. Final Weight, Lbs.	184.1	197.7	179.6	185.1
Avg. Initial Weight, Lbs.	74.6	73.6	72.9	74.6
Total Gain, Lbs.	109.5	124.1	106.7	110.5
Avg. Daily Gain, Lbs.	1.56	1.77	1.52	1.58
Feed Per 100 lbs. Gain, Lbs.	365.0	353.7	366.6	377.4
Free Gossypol Content of Meals, Per Cent	0.019	0.018	0.030	0.018
% Soluble Protein	20.0	48.6	16.2	48.6
Thiamine Content γ per gm.	10.0	14.8	9.8	14.8

*See Table 1 in Appendix.

**One pig removed from each lot due to unthriftiness.

***Same C.S.M. and same ration as in Lot 2 except that aureomycin and vitamin B_{12} were omitted.

***

Discussion

None.

***

NUTRITIVE VALUE OF COTTONSEED MEAL FOR CHICKS

by
H. L. Gorman, J. R. Reed, Jr., and J. R. Couch*
Texas Agricultural Experiment Station

Earlier studies have shown that cottonseed meal is deficient in lysine when this product is used as the protein concentrate in broiler rations. The present study was carried out to determine the value of cottonseed meal prepared by newer methods of processing and used at a level of 17-1/2 % in broiler rations. Three different cottonseed meals--No. 514 (mixture of Nos. 5 and 14, Series 5) S-12-T3 and a special solvent extracted meal--were used in these studies (See Tables in Appendix). The first two were supplied by the Southern Regional Research Laboratory, New Orleans, Louisiana, and the special solvent extracted meal was supplied by the Buckeye Cotton Oil Company, Cincinnati, Ohio.

Three experiments were conducted. The first two tests were carried out with New Hampshire chicks from the flock maintained by the Poultry Department, Texas A. & M. College System, College Station, Texas. Approximately 30 chicks were used in each group, and the chicks were maintained in batteries with raised screen floors. The third test was carried out with chicks kept on sand litter in a brooder house on Substation 21, of the Texas Agricultural Experiment Station, Gonzales, Texas. One hundred New Hampshire chicks, obtained from a local hatchery, were used in each group in the third experiment. Cottonseed meal No. 514 and the special solvent extracted meal were used in the first and second experiments. Cottonseed meal S-12-T3 was used in the third test.

The basal ration used in the first and second experiments consisted of soybean oil meal 35%, ground yellow corn 25-1/2%, ground milo 30%, steamed bone meal 2%, ground oyster shell 1-1/2%, dehydrated alfalfa leaf meal 3%, dried whey 2%, salt 1/2% and vitamin B_{12} and antibiotic feed supplement containing aureomycin 1/2%. In addition the diet was further fortified with 2 mg riboflavin, 9 mg niacin, 4 mg pantothenic acid, 10 mg of choline and 600 A.O.A.C. chick units of vitamin D_3 per lb. of feed as well as with 5 grams of manganese sulphate per 100 lbs. of feed. The above mentioned B vitamin levels were doubled in the third experiment.

It is apparent from the data of the first experiment that cottonseed meal No. 514 and the special solvent extracted meal can be used to supply 1/2 of the protein feed required in a broiler ration. Earlier studies have shown that cottonseed meal 514 produced a fair rate of growth when used as the only protein supplement in a broiler ration. Best results are obtained, however, when cottonseed meal is used at a level of only 17-1/2% in a ration for the production of broilers.

*Presented by Dr. Couch.

EFFECT OF FEEDING COTTONSEED MEAL 514* (MIXTURE OF MEALS 5 and 14) AND SOLVENT EXTRACTED COTTONSEED MEAL** ON THE WEIGHT AND FEED EFFICIENCY OF NEW HAMPSHIRE CHICKS AT 10 WEEKS OF AGE

First Experiment

Supplement to Basal Ration	Avg. Weight in Grams: Cockerels	Pullets	Feed Efficiency
None	1079	887	2.89
Cottonseed meal 514	1048	892	2.91
Cottonseed meal 514 (17.5%)+ Soybean oil meal (17.5%)	1098	967	2.61
Cottonseed meal 514 (17.5%)+ Soybean oil meal (17.5%)+ DL-lysine (0.3%)	1171	931	2.52
Special Solvent Extracted Meal	1010	898	3.14
Special Solvent Extracted Meal (17.5%)+ Soybean oil meal (17.5%)	1128	894	2.84

*Supplied by Southern Regional Laboratory, New Orleans, Louisiana.
**Supplied by Buckeye Cotton Oil Company, Cincinnati, Ohio.

It is apparent from the data of the second experiment that the growth obtained from the feeding of cottonseed meal or soybean oil meal can be further improved by the addition of fish meal. It is believed that the fish meal is supplying some as yet unidentified factor required for the maximum growth of the chick.

EFFECT OF FEEDING SOYBEAN OIL MEAL, SPECIAL SOLVENT EXTRACTED COTTONSEED MEAL* AND FISH MEAL ON THE WEIGHTS AND FEED EFFICIENCY OF NEW HAMPSHIRE CHICKS AT 10 WEEKS OF AGE

Second Experiment

Supplement to Basal Ration	Avg. Weight in Grams: Cockerels	Pullets	Feed Efficiency
None	1063	884	3.09
Special Solvent Extracted Meal	1041	884	3.14
Fish meal (3%) + Soybean Oil Meal (30%)	1118	987	2.71
Fish Meal (3%) + Special Solvent Extracted Meal (30%)	1096	856	3.29
Soybean oil meal (17.5%) + Special Solvent Extracted Meal (17.5%)	1136	881	2.85
Soybean Oil Meal (15) + Special Solvent Extracted Meal (15%) + Fish Meal (3%)	1199	960	3.14

*Supplied by Buckeye Cotton Oil Company, Cincinnati, Ohio.

A 50% protein soybean oil meal was used in the third experiment. The level of this meal was adjusted so that the protein content of the rations in the third test was approximately the same as that of those in the first and second experiments. It is apparent from the data of the third test that a mixture of soybean oil meal and cottonseed meal (17-1/2%) produced somewhat better growth than did this sample of 50% protein soybean oil meal. An increase in growth was observed when either the soybean oil meal or the soybean oil meal and cottonseed meal rations were supplemented with methionine, fish meal, and fish meal and methionine. Feed efficiency was improved by methionine supplementation as was the feathering of the chicks. It should be pointed out that the best feathered chicks were given a score 4.0. Therefore, the best feathering is indicated by the highest feather score. Growth and feed efficiency were particularly improved when fish meal was fed with methionine. Fish meal apparently contains a factor which is necessary for best methionine utilization. It is believed that the response obtained with the fish meal is due to an unidentified factor in this material and not necessarily to the amino acid content.

Cottonseed meal, manufactured by the newer methods of processing, can be used at a level of 17-1/2% in broiler rations with very good results. Growth can further be enhanced by the addition of 2% fish meal and 0.05% methionine to the cottonseed meal-soybean oil meal formula.

EFFECT OF ADDING METHIONINE AND FISH MEAL TO A SOYBEAN OIL MEAL RATION AND TO A SOYBEAN OIL MEAL--COTTONSEED MEAL* RATION ON THE WEIGHTS, FEED EFFICIENCY AND FEATHERING ON NEW HAMPSHIRE RED CHICKS AT 10 WEEKS OF AGE

Third Experiment

Supplement to Basal Ration	Average Weight in Grams: Cockerels	Pullets	Feed Efficiency	Feather Score
	50% Protein Soybean Oil Meal			
None	1146.81	1012.07	2.82	2.86
Methionine (.05%)	1175.29	990.40	2.77	3.29
Fish Meal (2%)	1232.96	1032.77	2.86	2.69
Fish Meal (2%) + Methionine (.05%)	1299.25	1069.05	2.62	3.22
One Half 50% Protein Soybean Oil Meal and One Half Cottonseed Meal				
None	1197.76	1033.43	2.88	2.77
Methionine (.05%)	1300.02	1072.89	2.81	3.28
Fish Meal (2%)	1265.15	1069.90	2.78	3.08
Fish Meal (2%) Methionine (.05%)	1327.22	1115.79	2.76	3.10

*Control cottonseed meal S-12-T3, supplied by Southern Regional Laboratory, New Orleans, La. See Tables in Appendix.

***

Discussion

None.

***

EVALUATIONS OF NUTRITIVE VALUE OF COTTONSEED MEALS AS SWINE FEEDS

by
J. C. Blight and N. R. Ellis*
Bureau of Animal Industry

At the 1950 conference at the Southern Regional Research Laboratory, results were reported on feeding tests completed up to that date. One trial was described covering comparisons of protein values in four meals of series 5 and designated 1 (See Table 1 in the Appendix), 9, 10, and 13. The average daily gains of the groups of pigs fed these meals were 0.88, 1.07, 1.21, and 0.99, respectively, as compared to 1.19 for the control group fed soybean meal. The rates of gain followed the same order as the values for soluble nitrogen in the cottonseed meals.

Because several pigs became lame on the cottonseed meal diets, a second trial has been conducted during the past year. The average daily gains were 1.37, 1.16, 1.34, and 1.29 for the cottonseed meals in the order already given as compared to 1.55 for the control group on soybean meal. These gain figures do not follow the same order as found in the first trial. Even though the rates of gain were somewhat greater, even more lameness was encountered among the pigs fed cottonseed meal. The disorder seems to have vitiated measurement of the protein values. This peculiar lameness appears to be associated with a factor or factors in the cottonseed meals and must be investigated further before testing of protein efficiencies can be resumed.

In addition, a rat feeding test to measure protein efficiency has been conducted in which the same four meals along with meal No. 16 of Series 5 and another meal designated as No. 10, Series 6 (See Appendix) have been compared with soybean meal. Results of this test show some variation between meals and in the same order as the soluble nitrogen values, thus indicating a close association of nutritive value of protein with soluble nitrogen. (See the following table).

RAT GROWTH RESULTS FROM A 4-WEEK FEEDING TEST ON C/S MEALS FROM SERIES 5

Lot No.	1	9	10	13	16	6-10	S.C.M.
No.animals/group	8	8	8	8	8	8	8
Avg.initial wt.(gms.)	55.5	55.6	55.6	55.6	55.5	55.5	55.6
Avg.total gain "	87.2	92.4	101.6	89.4	94.6	100.1	100.1
Soluble N % in meals	15.3	31.7	41.4	26.5	34.8*	70.7	

*Average of 16 and 16b.

*Presented by Dr. Ellis.

***

Discussion

Question: What ration was used for the hogs--was it synthetic?

Answer: 2/3 of the ration was yellow corn, 26 - 30% was cottonseed meal. It also contained alfalfa, a mineral mixture containing calcium and phosphorous at the levels recommended by the National Research Council. Pantothenic acid and riboflavin were added in the second round. In other words, it was a typical practical ration.

Question: Was any vitamin D supplement used?

Answer: No.

Question: Are the recommended levels for calcium and phosphorous too low for all types of rations?

Answer: Possibly - future studies should answer this question.

***

EXPERIMENTS ON GOSSYPOL IN DIETS FOR CHICKENS, AND ON PINK DISCOLORATIONS IN EGGS CAUSED BY SOME COMPONENT OF COTTONSEED

by
Burt W. Heywang
Southwest Poultry Experiment Station, BAI

During the past year experiments have been conducted at our station to obtain information on the level at which free gossypol has an adverse effect on egg production and the level at which it causes discolorations in egg yolks. In still another experiment cottonseed products were included in diets to determine if the component of cottonseed that causes pink discolorations in eggs is found in the oil, hulls, or pigment glands, and if certain solvents will remove the component.

The results of some of these experiments are indicative rather than conclusive, but it is felt that they are of enough interest to warrant discussion.

Egg production did not decrease when the dietary level of free gossypol was as high as 0.0124%, but did decrease when it was 0.0166% or more. Discolorations appeared in the yolks of a few fresh eggs when

the dietary level of free gossypol was as low as 0.005%, and in the yolks of a few eggs held in cold storage when the level was only 0.003%. Hatchability was not improved when several compounds with amino groups, or sardine meal, were included in diets containing 0.026% free gossypol.

No pink discolorations were found in the yolks or whites of eggs from pullets fed diets containing cottonseed hulls, methyl ethyl ketone extracted meal, iso-butane extracted meal, or a gossypol-glycine compound. Pink discolorations were common when the diets contained crude cottonseed oil or raw cottonseed meats.

In an experiment on the free gossypol tolerance of young chickens, two sets of seven diets each were fed to groups of 20 White Leghorn chicks. The base diet in one set contained 30% soybean meal as the only protein concentrate and the other six diets contained 30% cottonseed meal as the only protein concentrate. Partly because we were not certain that the soybean meal or the cottonseed meals would supply enough available lysine to the diets, the base diet in the other set contained 22% soybean meal and 5% sardine meal and the other six diets contained 22% cottonseed meal and 5% sardine meal. All 14 diets were of similar protein content. The same cottonseed meal was included in one diet in each set. The diets were fed for seven weeks. The results are seen in the following table.

EFFECT OF FREE GOSSYPOL ON THE GROWTH OF CHICKS

Free gossypol in diet		Average weights of chicks at seven weeks
	Diets containing no sardine meal	
.0000%	(The diet with no gossypol con-	256 g.
.0069	tained 30% soybean meal; the	308
.0141	other six diets contained 30%	257
.0186	cottonseed meal)	228
.0270		212
.0390		208
.0630		202
	Diets containing 5% sardine meal	
.0000	(The diet with no gossypol con-	360
.0051	tained 22% soybean meal and 5%	320
.0103	sardine meal; the other six diets	341
.0136	contained 22% cottonseed meal and	353
.0198	5% sardine meal)	331
.0286		284
.0462		265

In all instances where comparisons were possible, higher average weight was obtained on the diets containing sardine meal than on the diets not containing it. This indicates that the seven diets not containing sardine meal were deficient in some factor, or factors, necessary for growth. It seems probable to me that the diets were deficient in lysine.

However, the level at which free gossypol retarded growth seems in the same general range on both sets of diets. When the diets did not contain sardine meal, the level at which free gossypol retarded growth was between 0.0141 and 0.0186%. When the diets did contain sardine meal, the level at which free gossypol retarded growth was between 0.0136 and 0.0198%.

In my opinion, more data are needed before we can say much about the level at which free gossypol retards the growth of young chicks. Mortality was low in all 14 groups. Deaths that did occur apparently were not attributable to the free gossypol content of the diets.

***

Discussion

Question: Was gossypol added to a soybean basal diet, in the experiments with laying hens?

Answer: Yes.

Question: What was the source of the gossypol?

Answer: It was added as raw decorticated cottonseed containing 0.83% free gossypol.

Question: Were the diets analyzed for gossypol after mixing?

Answer: No. The components were analyzed before incorporation in the diet.

Question: Can the discoloration in fresh eggs be seen without exposing them to ammonia?

Answer: Yes.

Question: Can you get a gossypol test on discolored egg yolks?

Answer: Haven't tried to get such a test.

***

COMPARISON OF IN VITRO AND IN VIVO METHODS OF PROTEIN EVALUATION OF COTTONSEED MEALS

by
Madolyn Womack
Bureau of Human Nutrition and Home Economics

The protein quality of a number of cottonseed meals has been studied by feeding the meals at a level of 10% protein to young rats in an otherwise adequate ration. The protein efficiencies (grams gain per gram of protein eaten) varied from a low of 0.54 in a badly overheated meal to a high of 2.87 for a solvent extracted meal. At the same time, the meals were subjected to acid hydrolysis and amino acid analyses were made by microbiological assay to determine whether or not there was any correlation between the amino acid content of the meals and their nutritive value.

The badly overheated meal with a protein efficiency of 0.54 had a lysine content, calculated to 16% nitrogen, of 3.98%, while a solvent extracted meal, with a protein efficiency of 2.64 had a lysine content of 4.74%. However, three other meals, with lysine values of 4.75, 4.76, and 4.80 had protein efficiencies of 1.70, 2.01, and 2.28. Moreover, the values for most of the other amino acids, except those for methionine and possibly histidine, were within the limits of experimental error of the amino acid assay method. It was apparent that little information on the nutritive value of the meals could be obtained by determining the amino acid content after acid hydrolysis.

When the amounts of the amino acids liberated by enzymatic hydrolysis were determined by microbiological assay, larger differences were found in the amino acid analyses of the various meals. The amount of lysine liberated varied from 0.81% to 2.38%, and the high and low values were found for meals with high and low protein efficiencies. However, there was no correlation of protein efficiencies with the lysine liberated by the enzymes in the intermediate ranges of protein efficiencies. A similar picture was obtained for the amounts of methionine found after enzymatic digestion. (See the following table.)

Comparison of the Lysine and the Methionine Contents* (Enzymatic Hydrolysis) of Cottonseed Meals with Their Protein Efficiencies.

Lysine %	Methionine %	Protein efficiency gm.gain/gm.protein eaten
0.81	0.40	0.54
1.10	0.50	2.01
1.53	0.57	2.28
1.67	0.58	1.70
--	1.12	2.50
2.38	--	2.64

*Calculated to 16 percent nitrogen.

If the values obtained after enzymatic hydrolysis for all ten of the "essential" amino acids from meals which had undergone various processing conditions are compared with the amounts liberated from an unheated meal, a nutritive index can be obtained from the in vitro experiments. The total of the amino acid values obtained for the solvent-extracted meal is taken as 100 and the values obtained from the other meals related to it. Similarly, the protein efficiency of the solvent-extracted meal is called 100 and the protein efficiencies of the other meals related to it. In this manner nutritive indices from in vitro and in vivo experiments can be compared. The results obtained with one series of meals are given below. The results do not show complete agreement for all the meals but they indicate that an amino acid analysis after enzymatic hydrolysis may be of some value in assessing protein quality.

Nutritive Indices (Series 1 Meals)*

Cottonseed Meal No.	From microbiological studies	From rat growth studies
8	87	86
7	83	80
6	82	90
9	76	68
1	75	73
4	75	68
3	71	69
2	70	80
5	59	22

*See Table 3 in the Appendix.

***

Discussion

Question: How was the amino acid composition of the meals, as determined by the microbiological assays, evaluated?

Answer: The average values of the 10 essential amino acids were compared with those obtained for solvent extracted meal which was arbitrarily assigned the value of 100.

Question: Was the solvent extracted meal used a methyl-ethyl-ketone meal?

Answer: Yes.

Question: At what protein level were the rats fed?

Answer: 10% level.

Question: How long were they fed?

Answer: 6 weeks.

Question: Would a higher level of protein in the diet show the difference in protein quality better?

Answer: Probably not as well, as differences would be leveled out. If higher levels are used gossypol effects may confuse the results. The 10% level of protein seems to be optimum for studies of this type.

Question: Do rats show less susceptibility to gossypol than other animals?

Answer: Yes.

Question: Were there other differences in the meals?

Answer: There were differences in the methods of preparation, as well as differences in thiamine values and in nitrogen solubilities. Thiamine was thought to be a possible index of protein quality, rather than a critical component of the diet.

Question: Does thiamine predict protein efficiency better than soluble nitrogen?

Answer: In our experiments the protein quality was correlated more with thiamine content than with nitrogen solubility. For the limited number of observations on rats this is true but the number of observations is too small to draw general conclusions.

(A general discussion of the importance of standardizing the protein content of experimental diets followed).

*****

ROUND TABLE DISCUSSIONS

WHAT ARE THE LIMITS OF FREE GOSSYPOL CONTENT THAT AFFECT THE VALUE OF COTTONSEED MEAL IN HOG AND CHICK FEEDS?

Discussion Leader: J. R. Couch

Couch

Three main points can be summarized from our discussions yesterday. First, there is a decided state of confusion in our minds about the limits of free gossypol in cottonseed meal that will affect the nutritive value. Second, it is apparent that in all future experiments the gossypol content should be determined. Since, as F. H. Smith reported, 0.046 and 0.052% gossypol showed no difference in the effect on growth, it seems highly important to know the gossypol content at all times. Third, all investigators should use the same basal ration. One step in this direction is that all investigators are now to use the same soybean oil meal - produced by Central Soya.

It is a well recognized fact that gossypol will inhibit growth and in some cases cause death, but our results vary. Hale at Texas A. & M. found that 0.06% gossypol will kill pigs and 0.04% will retard growth. Boatner reported in 1948 that 0.13% gossypol did not inhibit growth; Bird in 1949 that 0.063% did. Heywang has reported inhibition of growth with much less than 0.06% gossypol. All this would seem to indicate that the ingredients of the diets were not controlled.

Two investigators yesterday reported on the addition of 0.4% lysine; in one case the effect was good, in the other it was not. It is perhaps suggested that lysine detoxifies gossypol - that gossypol uses up some lysine.

In order to obtain uniform results, we need a uniform ration for pigs, chicks, and hens, so that we may be able to study the effects of only one variable - the percent of free gossypol.

Altschul

Before further discussion, it should be clearly understood what is meant by "free gossypol." We define it as that amount of gossypol that is readily extractable by aqueous acetone according to the official A.O.C.S. method developed by Pons and Guthrie. We must clearly define this term since, obviously, different methods of analysis will produce different results.

Heywang

On the subject of the level of gossypol in feeds for baby chicks, I must reiterate that the data obtained were indicative rather than conclusive. Ingredients used in the basal diet for chicks included

sardine meal, ground maize and 5% alfalfa meal. Some limestone, fermentation solubles, and vitamins A and D were added.

In one series soybean oil meal was used and raw decorticated cottonseed was added in different calculated amounts to furnish the desired levels of gossypol in the diet. With a diet with 40% cottonseed meal of 0.0132% free gossypol content, I would not attribute the slow growth to gossypol.

Results of two series of feeding tests were:

Basal Diet	Range of Free Gossypol (%) Levels Tested	Level of Free Gossypol (%) Causing Growth Inhibition
(1) 30% S.O.M) with no added 30% C/S M) sardine meal	0.0069% - .063%	0.0141%
(2) 22% S.O.M) with 5% added 22% C/S M) sardine meal	0.0051% - 0.0462%	0.0286%

Better growth was obtained with the diets containing 5% added sardine meal; this effect may have been due to lysine present in sardine meal tying up gossypol. No chicks died in any of these experiments, but there was definite growth inhibition with some of the diets.

Alderks

Based on your (Heywang's) results, a level of 0.04% free gossypol in cottonseed meals used in diets for growing chicks is O.K.

Heywang

Yes, provided enough lysine was present in the diet. With sufficient lysine the level of free gossypol in the meal which would be fed safely might be higher than without the lysine. We probably could recommend to commercial poultry men that they use cottonseed meal as the sole source of supplementary protein if enough lysine is added to the basal diet from another source.

Eagle

What level of cottonseed meal of this (0.04%) gossypol content may be fed?

Heywang

30% cottonseed meal of .04% gossypol may be fed; meal containing 0.08% gossypol may not be fed at the 30% level but may possibly be fed at the 15% level. I might mention that hydraulic-press cottonseed meals

in Arizona always have a lower gossypol content than meals prepared by the same method in the South. Commercial screw-press meals usually have about 0.04% gossypol.

Kuiken

Is the gossypol content of seed lower in this area?

Heywang

Raw meats have been analyzed to give 0.83% gossypol.

Question: Does anyone have data on seed from other localities?

Altschul

Some run as high as 1.2%.

Lyman

Meats at College Station usually are approximately 0.8 to 0.9% gossypol; which is less than for those in the East where the gossypol content is usually greater than 1%.

Heywang

Raw meats were not ground until they were put into the diet; they were not ground in large quantities and stored. We used an old coffee grinder.

Rusoff

In the second experiment (with sardine meal), the growth rates are higher. Would you say that faster growing birds perhaps tolerate a higher level of gossypol in their diets?

Heywang

I would suspect that it was because the diet was better.

Rusoff

Some investigators use B_{12} and antibiotics. Perhaps we should re-evaluate our diets to see if faster growing birds can tolerate more gossypol with such additions.

Heywang

Different hens have different tolerances to the amount of gossypol in their diets; and we need to use large numbers to eliminate individual differences. I never found the addition of B_{12} to stimulate growth when using cottonseed meal.

Alderks

How was the mash fed, dry or wet? My reason for asking this question is the fact that cottonseed meal is usually ground to pass 60 or 80 mesh. It is questionable whether or not the chicks would eat very fine cottonseed meal during the feeding test.

Heywang

We used an all mash diet - dried. Used a type of corn--milo--which ground better, so as to make the mash more homogeneous. Therefore, chickens had very little chance to leave any.

Couch

To sum up, it seems safe to use cottonseed meal containing 0.04% gossypol as 30% of the diet of growing chicks - limited only by the level of lysine which can be supplied in the diet by added natural sources, since there is no cheap method for the production of lysine commercially. We need to standardize the B_{12} and antibiotic additions, as well as other vitamins.

Heywang (to Dr. Morgan)

Is it true that you also had no mortalities as a result of feeding gossypol?

Morgan

Yes, that's true; however, the level of gossypol was never over 0.04%. Meals used were all of practically the same gossypol content. Evidently, when slower growth occurred on diets containing 0.04% gossypol, this was not due to gossypol, but to some other factor.

Wallace

What is the fate of bound gossypol? What do we know of the combination of gossypol with the components of the meal? Does the combination go through the digestive system of the animal unchanged?

Lyman

Bound gossypol, that is, bound by natural constituents of the meal, passes through the chick unchanged.

Couch

Dr. Kuiken, will you comment on the fate of gossypol bound by artificial means in your "degossypolized" meal?

Kuiken

Gossypol in our product is very tightly bound. There is no question but that such gossypol goes through the digestive system in its bound form.

Eagle

With respect to bound gossypol, we have studied combination products of gossypol with glycine, dextrose and protein. These were administered to rats by stomach tube to be certain that there would be no question of intake.

Those bindings do not cause differences in acute oral toxicity except for difference in the free gossypol content. However, the gossypol content of a mixture is no indication of toxicity. I have always found cottonseed pigment glands more toxic than gossypol alone. I believe there is something in pigment glands more toxic than gossypol.

Kuiken

Has the toxicity of gossypol combination products ever been evaluated in terms of solubility? Gossypol toxicity may be modified by other components of a diet. I seriously question that amines (amino acids) and gossypol will combine tightly enough to withstand digestive juices. There is no measure of how much gossypol enters the blood stream, and this is seriously needed.

Is the solubility of gossypol increased by combining it with glycine, in the form of the gossypol-glycine complex? Can we change the toxicity of gossypol by adding something to the basal diet, for instance, surface-active agents?

Altschul

I am not in agreement with Dr. Eagle. In collaborative work with Dr. Boatner, Dr. Eagle found that he could not get as high an acute oral toxicity, on rats, with gossypol as with pigment glands. These results could be interpreted in the following ways:

(1) There is something in the pigment glands more toxic than gossypol; or (2) gossypol, as it exists in the pigment glands, is not in the same form as insoluble, pure gossypol.

Fractionation of pigment glands, with the intention of finding one fraction more toxic than gossypol, was attempted, but with no success.

The second approach tried was to react gossypol with other substances to make complexes, or "compounds," in order to see if we could change the toxicity of gossypol. Tests on goldfish showed a difference in toxicity of these complexes compared to that of gossypol; the complexes were more toxic. One complex, prepared by reacting equal parts by weight of gossypol and glycine, was sent to Dr. Eagle and also to Dr. Martin of Tulane University for feeding tests.

Dr. Martin could not kill mice with as much as 12 g/kg. body wt. of the glycine complex. When he fed mice a solid mixture of gossypol and glycine, he found it to be toxic.

Dr. Eagle tested several different gossypol glycine complexes, containing different ratios of gossypol to glycine. Dr. Martin found that one complex, gossypol dextrose, seemed to have a greater oral toxicity on mice than did gossypol. I do not believe it is necessary to postulate the existence of some material in pigment glands which is more toxic than gossypol itself.

Eagle

I disagree.

I tested a sample of gossypol-dextrose and found it to have an LD_{50} higher than gossypol, or to be less toxic than pure gossypol. LD_{50} is defined as that amount of the material tested which will kill half of the animals within a specified length of time.

The following results were obtained when different samples of gossypol complexes were fed to rats:

Complex	Ratio of gossypol:glycine	LD_{50} (mg/kg)	% Gossypol
Gossypol-glycine	1:9	> 6000	7.1
" "	1:1	> 6000	32.5
" " 1/	9:1	2355	52.5
Gossypol-dextrose 2/		3725	38.2
Gossypol-peanut protein		3220	32.5
Gossypol (100%)		2720	100
C/S Pigment glands 3/		2170-925	28.6-40

1/ Gossypol-glycine (9:1) found to have slightly lower LD_{50} than gossypol, but difference is not significant.

2/ Gossypol-dextrose found to be less toxic than gossypol.

3/ Tested a number of samples of cottonseed pigment glands of different gossypol content, but found that toxicity of the pigment glands could not be correlated with % gossypol in the glands.

Kuiken

In the gossypol-glycine complex of ratio 9:1, does that mean that the gossypol content is 90%?

Karon

No, the molar ratio in that complex is app. 7:1.

Eagle

The percent of gossypol in that sample is 52.5%.

Kuiken

Yet that sample was found to be more toxic than 100% gossypol. Is it more soluble, thus more toxic?

Altschul

Yes, solubility might be the answer.

Eagle

Sometime ago, it was suggested that gossypol might be used as an appetite depressant for humans, and thus might be a possible cure for obesity. Unfortunately, when we tested gossypol on dogs, it was found that very small chronic doses killed all of them.

Castillon

Gossypol dextrose, when fresh, is light in color and water-soluble, but on storage becomes darker and less soluble. The sample that Dr. Martin tested was fresh, whereas the sample Dr. Eagle tested had been stored for a while. This might explain the difference in toxicity they obtained upon testing their samples of gossypol-dextrose. Dr. Martin found that within 3-weeks' storage of gossypol-dextrose, its toxicity had decreased.

Altschul

In these various complexes, the analysis for free gossypol, by the p-anisidine method, may not give a completely accurate picture of the amount of gossypol actually bound in the complex. The aqueous acetone used in this method may break the binding of gossypol and the other material sufficiently to give a higher percent of free gossypol than is actually present. Several different binding agents were used, therefore the character of the bond might vary from one complex to another.

Lyman

It is possible that the various forms of gossypol have different toxicities. Pure crystalline gossypol is insoluble in water; however, gossypol, as released from pigment glands by treatment of the glands with water, is in colloidal suspension in water, which is probably due to the fact that gossypol exists in some loosely-bound state in the glands. The form of "free gossypol" as it exists in one meal may differ in toxicity from that in another meal. For example, two meals, both containing 0.04% free gossypol, but processed by different methods, may have entirely different effects on growth. A parallel toxicity study of meals produced by different processing methods is needed.

Ward

Free gossypol in raw meats may have a different toxicity from that in cottonseed meals.

Alderks

The average free gossypol content of raw cottonseed meats is about 1%.

On the basis of the average size of a single pigment gland, I calculated the number of pigment glands in a ton of cottonseed; it came out to be 36 billion pigment glands per ton of seed. Most of these glands must be broken in order to detoxify the gossypol present. When a meal is obtained which has 0.01% free gossypol, does that mean that there are still 1/100th of the original pigment glands still intact--360 million?

Is the "free gossypol" we measure in cottonseed meal in unruptured glands or not?

Thurber

It must be remembered that the "free gossypol" of which we speak is that gossypol which is soluble in 70% aqueous acetone, and different methods of analyzing for "free gossypol" will produce different values. Therefore, we should all use the same method for gossypol determinations. These determinations should be made at the time of feeding, as it has been found that when cottonseed meals stand, the free gossypol decreases, especially those with higher free gossypol content and when the meals have been mixed with the remainder of the ration. It is again pointed out that all should use the same ration.

Meals sent to Dr. Heywang had very few whole pigment glands. However, when raw seed was used as the source of gossypol, the situation is different, as very few glands are broken when raw seed is merely ground.

Pominski

As it is known that p-anisidine reacts with other pigments to give the same reaction product as gossypol, it seems as if we should have a method for the determination of gossypol alone. In this way we might be able to distinguish between two meals which both have 0.04% free gossypol as measured by the p-anisidine method, but which have different effects on growth.

Eagle

I would suggest to those who work with chicks that they add pure gossypol to the diets. I found 0.05 to 0.1% the critical level for rats.

Heywang

We added gossypol in mixed diet to chicks. We found that by the end of the experiment most of the gossypol had disappeared.

Eagle

Did you keep the diets in a cooler?

Heywang

No.

Karon

We have just completed a study where we added pure gossypol to diets. We definitely found a disappearance of gossypol. The loss was greater in diets high in alfalfa.

Barrentine

At Mississippi College, we checked the gossypol content of diets at various stages during storage and also found a definite destruction of gossypol in the presence of alfalfa. Even when a mixture was analyzed immediately, we never recovered more than 80% of the gossypol originally added.

We need more study on methods of analysis of mixed diets.

The iron content seems to have some effect on the disappearance of gossypol.

We definitely need to have work done on the determination of the specific physiological action of gossypol. The symptoms seem to resemble deficiency conditions. Is it cumulative?

Rusoff

The limiting factor seems to be an analysis for gossypol. We have no true method of analysis for gossypol.

Couch

We have little data on toxicity for swine. They are too big for LD_{50} determinations.

What have you to say about swine, Mr. Ellis? Tell us about your plans for future tests.

Ellis

The meals which I have previously tested varied in gossypol content from 0.03 to 0.09%.

The tests that I have planned will be based on the free gossypol content of the diet rather than the meals. We would like to work with these levels in the diet -- 0.005, 0.01, 0.015, 0.02 and 0.03. The toxic level as reported in the literature is about 0.015% of the diet. We could use 25% of cottonseed meal containing 0.08% gossypol.

Stephenson

The use of swine as a laboratory animal is very expensive.

What is the mechanism? It appears as if it might be a deficiency, as animals do not show effects until they have been on test for about 30 days.

Fletcher

There is a tremendous variation in the tolerance to gossypol in swine. As we are limited in the numbers of animals we can use, it is difficult to determine minimum lethal doses. We definitely need standard conditions for toxicity studies on swine.

We made some studies on the changes in gossypol content of diets containing varying amounts of alfalfa. The alfalfa meal replaced corn in the diet. As alfalfa meal was increased, the decrease in gossypol was greater. However, there was no definite quantitative correlation between the increase in alfalfa and the decrease in gossypol. We found that you do not get the same effect with corn as with alfalfa. We suspect a combination or artifact to explain the disappearance of gossypol. There is a decrease in total gossypol as well as in "free" gossypol. There is always an immediate decrease in gossypol content, but no indication of a continued decrease.

We should give consideration to the level of gossypol in the ration itself rather than in the cottonseed meal used.

What is the significance of the third decimal place in gossypol determinations?

Hoffpauir

This depends on the amount of gossypol present. If the amount of gossypol is 0.02% or lower, then the third place is significant. Higher amounts of gossypol are significant only to the second place. For the highest precision, a standard curve for each level of gossypol should be established by the analyst applying the method.

This method was designed for the determination of free gossypol in cottonseed meal and cottonseed products.

When it is applied to mixed diets, it is probable that there are a number of different interfering materials.

An investigation of the application of this method or any other method to mixed feeds is needed.

Alderks

In the range of 0.02 - .04% free gossypol, what is the standard deviation in a single test?

Hoffpauir

It is possible to reproduce duplicate analyses within two or three figures in the third decimal place, or 10-15% absolute.

Lyman

Dr. Ellis' analyses on total ration were carried to the third decimal place. It should be noted that in most instances the analyses were made on the meals before mixing in the rations and the content of gossypol in the rations was computed. Hence, with the higher level in the meals the third place is more significant.

Couch

To summarize, I believe that we may say that:

(1) Standardization of diets is needed. From the results of feeding tests at present, it would appear that; the toxic level of gossypol in the total diet for growing chicks is 0.015 - 0.02%, supplied by 30% cottonseed meal containing 0.04% gossypol. However, these figures mean very little unless the diet is standardized.

(2) Gossypol causes mortality in swine, but not in chicks at the levels fed.

(3) A method for analysis for gossypol in mixed feeds is needed.

In future discussions I would like to suggest use of the term "growth-promoting activity" rather than "toxicity." From a practical standpoint, this is advisable particularly when speaking to commercial feeders.

Ward

I endorse use of the term "growth-promoting activity" rather than toxicity, and I consider the standardization of diets so important that I would like to appoint a committee immediately to draw up standard diets for chicks, swine and laying hens. * I appoint Dr. Couch as chairman of this committee, which will consist of the following men:

Watts	Harper
Kuiken	Stephenson
Bird	Wallace
Morgan	Smith
Ellis	Heywang

Kuiken

I would say that we left the swine picture more indefinite than it really is. I obtained the following results in two series of tests, feeding swine cottonseed meal as the sole source of protein in the diet for an 84 day feeding period:

% gossypol in C/S Meal	% gossypol in diet	Level of C/S Meal in diet	Growth (lbs/day)
0.073	.022	30	1.6
0.04	---	30	1.7

The level of protein in the diet was adjusted as the animals grew; therefore, the original gossypol level was not maintained throughout the entire feeding period.

I would like to stress the importance of performing feeding tests on swine with weanling weight animals.

---

* For the recommendations of this committee, see the appendix.

Smith

I fed one cottonseed meal at a 37% level to swine and obtained an average of 0.24 lb/day daily gain; these animals lived but showed no growth.

When 0.5% APF was added to the diet, the animals showed good gains for a while, but then died.

In another test, the gossypol content of the diet was 0.054%. In this test, the animals grew nicely for three weeks but then died.

When another cottonseed meal, which contained 0.046% gossypol was used in the diet, bringing the gossypol content of the diet down to 0.01%, excellent results were obtained. The daily gain was 1.84 lb.

Couch

It may be concluded, then, that the level of gossypol in the total ration for swine is the same as that for chicks--0.012-.015%.

Altschul

Meals sent to Heywang for feeding tests were obtained by blending screw-pressed meal containing 0.03% free gossypol with a solvent-extracted meal containing 0.5% free gossypol.

Time seems to be an important factor in the free gossypol content of a cottonseed meal.

We should supply more meals like those given to Heywang to other investigators.

What Mrs. Pominski said is true, and the method for the determination of free gossypol which we use must be applied carefully. Since no better method is available, however, we will continue to use this one.

From Dr. Eagle's results, it would appear that we should investigate further the chemistry of these combination products of gossypol which he tested.

As Mr. Hoffpauir indicated, we need a method for determining the percent of free gossypol in mixed diets.

WHAT ARE THE LIMITS OF FREE GOSSYPOL CONTENT THAT AFFECT THE USE OF COTTONSEED MEAL IN MASHES FOR LAYING HENS?

Discussion Leader: Francis Bird

Bird

It seems to be agreed that the determination of the limits of free gossypol to be used in laying mashes presents the same problems as with growing chicks.

Stephenson reported that some cottonseed meals which he tested gave good egg production, but the eggs showed discoloration on storage.

Hatchability, apparently, can be reduced by the feeding of cottonseed meal.

Due to the unfavorable impression the public generally has about feeding cottonseed meal to laying hens, we shall have to reeducate poultrymen that properly prepared cottonseed meal is a good feed ingredient.

There are several questions and problems which should be discussed today.

1. What is the ultimate effect on the laying hen of feeding cottonseed meal to the growing chick?

2. Disregarding the gossypol problem, can cottonseed meal be safely used as a replacement for other proteins in laying and breeding mashes?

3. How safe is it for laying hens? (Heywang's best results show 4% discolored eggs.)

4. What is its effect on hatchability? How safe is it for breeders? Is there any carry-over effect from the dam to the baby chick?

Heywang

With 0.005% gossypol in the diets, we obtained considerable discoloration in fresh eggs; and even with 0.003% gossypol in the diets there were still a few discolored eggs. We must, therefore, stay below this level. The source of gossypol in our diets was raw, decorticated seed.

Bird

Have you tried lower levels than 0.003% level?

Heywang

No.

Bird

We do need more data, then, indicating the maximum level of gossypol that can be tolerated in laying mashes. From a commercial standpoint, one discolored egg is as bad as several.

Ward

Mr. Heywang, have you progressed, or do you feel discouraged.

Heywang

I definitely feel encouraged. We know that cottonseed meal can be used for growing chicks and we can solve the discoloration problems with more work.

We have progressed more in the last two years with the cooperation of the SRRL than ever before.

Bird

Is there any evidence of storage of gossypol in chickens? If the feeding of cottonseed meal to growing chicks were discontinued just before hens started laying, would there be any carry-over causing egg discoloration?

Heywang

Most probably not.

Couch

What we need is a life-cycle experiment. Mr. Heywang is the best equipped to carry this out.

Heywang

We have tried it, with cottonseed meal as the sole source of meal, but had to discontinue the experiments, as there was not enough lysine in the diet. We shall try again, using other protein supplement combinations as cottonseed meal and fish meal is known to give good results.

Couch

Yes. I realize that cottonseed meal cannot be used as the only protein supplement in the diet because of the deficiency in lysine.

Heywang

I discontinued the experiment, but I haven't given up yet.

Kuiken:

Would you get the same results if you combined soybean oil meal and cottonseed meal to get the desired gossypol content in the diet?

Heywang

I don't know. In all my experiments I obtained the desired free gossypol level in the diet by adding raw decorticated cottonseed.

Kuiken:

I have tested "de-gossypolized" cottonseed meal at a level of 0.003% gossypol in the diet, and 20% of the eggs from hens fed this diet were discolored after 6 months storage.

Gastrock

Perhaps at this low gossypol level, it is a question of mixing. That is, those hens producing discolored eggs may have gotten more of the gossypol during feeding than the other hens if the diet was not homogenous.

Since laying hens appear to be the most sensitive to gossypol, could we possibly use a parallel feeding test on laying hens as a control on the chemical test.

Heywang

It might be possible if yolk discolorations were used as the index and not hatchability or egg production.

I would like to say that I am very glad to have confirmation of my findings from Dr. Kuicken.

Fletcher

I wonder about the reliability of yolk discoloration as a test for content of gossypol in the egg. It would appear that a method for analyzing eggs for gossypol content is needed.

Altschul

Nothing is known about gossypol in discolored eggs. The discoloration is believed to be produced by a reaction of gossypol with iron or other metals present.

Watts

In 1939 Swenson and Fieger reported a test for gossypol in discolored eggs. They exposed the egg to ammonia and thus precipitated the discoloration. They found that the discoloration is effected by a change in pH and will disappear when treated with acid. They reported the discoloration to be a protein-iron-gossypol complex sensitive to changes in pH. This could possibly be used as an index for gossypol content.

Stephenson

With hens fed a diet containing 0.002% gossypol, I found no yolk discolorations in 208 eggs and only one with a pink albumen.

Morgan

After 30 days storage I found no discoloration in eggs produced by hens fed cottonseed meal containing 0.03% gossypol at a 30% level in the diet.

Bird

In summarizing, the data presented at this meeting and during this discussion period indicate that a dietary level of approximately 0.002% free gossypol must not be exceeded if there is to be no effect on the color of eggs during storage. Dr. Heywang's data indicate that the 0.003% level has produced a few, though not serious, discolorations, while many eggs were discolored when the level reached 0.005% gossypol in the hens' diets. Dr. Stephenson found no egg yolk discoloration when diets containing 0.002% gossypol were fed. On the other hand, Dr. Morgan found no discoloration at a level of 0.009% gossypol in the diet. Hence, we find some disagreement as to the lower level which can be tolerated. Thus, more work with laying hens is indicated.

The discussion yesterday indicated that hatchability can be reduced by the feeding of cottonseed meal. More data are needed on the effect of cottonseed meal on breeder hens.

More work is needed particularly with regard to long term experiments feeding cottonseed meal throughout the life-cycle of the chicken.

Our discussion only touched on the problem of the comparison of cottonseed meal protein with other protein supplements. It was brought out that cottonseed meal is deficient in lysine. Some study might be made of the amino acid profile in cottonseed meal and the best combination to make with other protein concentrates to give the best feeding results.

WHAT IS THE EFFECT OF PROCESSING CONDITIONS ON THE PROTEIN VALUE FOR HOGS, CHICKS, AND CATTLE OF MEALS CONTAINING 0.03% OR LESS FREE GOSSYPOL?

Discussion Leader: N. R. Ellis

Ellis

During the past three years much work concerned with the effects of processing on the feeding value of cottonseed meals has been done. Most of this work has been on screw-pressed meals. The greatest concern has been with cooking temperatures, with emphasis on those ranging from 160 to 240 degrees F., but studies also have evolved around the time of cooking and the amperage on screw presses. Some of the reports given at this conference have been concerned with hydraulic-pressed and solvent-extracted meals, as well as with screw-pressed meals. A few individuals also have reported on work with gland-free meals.

In general the research to date indicates that moderate temperatures of cooking have tended to produce high quality meals. In chick feeding tests, screw-pressed meals produced at 200 degrees F. have proved equal to soybean meals and superior to cottonseed meals prepared by the use of higher temperatures. Still better meals probably can be produced.

Altschul

That milder conditions of processing gave better meals for growing chicks has been confirmed by Dr. Morgan's report on the screw-pressed meals he used. On the other hand, Dr. Stephenson found that screw-pressed meals were inferior to hydraulic meals for feeding lambs. Dr. Bird found no difference between butanone-extracted meals and screw-pressed meals in broiler rations. Dr. Womack reported interesting results with rats fed screw-pressed meals. Mr. Kuiken has told of successful feeding tests with "degossypolized" meal for hogs and chicks. In these reports several people have pointed out differences in the availability of lysine that might be related to the method of processing. These various results with different meals suggest the question: How much should we worry about heating as far as the practical value of the meal is concerned?

Bird

Lysine is one of the most difficult dietary elements to supply adequatly to chicks. Anything that can be done to save this amino acid in processing should be done.

Ellis

In the discussion this morning it was brought out that lysine affected the amount of cottonseed meal that can be used in the diets of chickens. This may be important since, in some years, processors may be interested in preparing chick rations containing a large amount of cottonseed meals, because other meals are not available.

Question

What type of meals were used in the lamb feeding experiments that have been reported?

Stephenson

The screw-pressed meal used in the lamb feeding experiments was Series 5, No. 12. The hydraulic meal was a commercial meal. The lambs gained 1/2 to 2/3 lb. a day, which were good gains. I am not sure whether we were measuring protein or carbohydrate or fat effects in these tests, for the carcasses seemed to fatten, but did not grow.

Question

How was the hydraulic meal prepared?

Alderks

If the meal came from one of our mills, it probably was prepared by the standard procedure used in all of our mills. That is, a 5-high stack cooker is used. The flakes are brought up to temperature as rapidly as possible in the top cooker. The flakes are cooked from 190 to 235 degrees for a total of 90 minutes, pressed at 4000 p.s.i. for 60 minutes. The cake is cracked and ground and brought to a 41% protein level.

Question

Did Dr. Morgan perform his experiments all at one time or were they performed at different times of the year?

Morgan

All at one time. The meals which gave the best growth gave poorer hatchability.

Larson

We are interested in the protein value of cottonseed for use in survival rations. The protein should be the highest quality possible. In a discussion of processing conditions, however, the sugars present in cottonseed cannot be disregarded. Raffinose and other sugars present in cottonseed are apparently broken down to reducing sugars during cooking. If proteins are heated in the presence of reducing sugars, the

feeding value drops greatly. The amino acids are tied up by the reducing sugars on heating. Thus, your lysine is tied up.

Kuiken

Laboratory designed experiments indicate that cottonseed should be processed under heat conditions that are optimum for the soy industry. The heat effect has been studied for soy extensively. Lysine disappears on heating soybeans during processing. This effect is not as pronounced for cottonseed. Samples varying by as much as 10% lysine were few. The presence of oil or gossypol is critical. Where they are absent, heat at 225 to 230 degrees does not seriously reduce amino acids, nor destroy more than 10% of the lysine.

Womack

In our experiments with Series 5 meals, where the temperatures varied from 160 to 230 degrees, the only one which showed a significant difference was the one prepared at 230 degrees. The rest were statistically equivalent. There was no difference between meals prepared at 160 and 200 degrees.

Ellis

What about differences between solvent-extracted meals?

Altschul

The purpose of the extracted meal series was to minimize heat while varying the gossypol content, and the solvents were selected for the purpose of recovering different amounts of gossypol. The protein in these meals should be near that of raw meals.

Kuiken

Some improvement over raw meals, very small in rat tests, can be produced by mild heat treatment.

Newby

Where do pre-pressed solvent-extracted meals fit into this picture?

Altschul

As far as the effects of heat on protein are concerned, they fall between screw-pressed and hydraulic-pressed meals.

Fincher

Since there are two screw pressing systems (French and Anderson) in use in this country, something should be said about time as well as temperature in evaluating the effects of cooking.

Newby

Have any feeding tests been made on meals obtained by the combined pre-pressing, solvent-extracted method?

Altschul

These are to be included in future studies.

Ellis

To summarize: the experiments to date, for the most part, indicate that low temperatures of cooking (around 200 degrees F.) are favorable to nutritive value in processing screw-pressed cottonseed meals. Meals of low gossypol content have been produced at this temperature.

Lysine is a critical nutrient in the preparation of cottonseed meals having high quality protein. Heating tends to tie up the lysine presumably through union with some other constituent such as gossypol, or reducing sugars. It is evident that the nature of this tie-up and the means of keeping loss of available lysine as well as other amino acids to a minimum need further investigation.

****

WHAT IS THE EFFECT OF SUPPLEMENTING COTTONSEED MEAL WITH AMINO ACIDS? HOW DO MIXTURES OF COTTONSEED AND SOYBEAN MEALS COMPARE TO EITHER USED ALONE?

Introduction: N. W. Flodin
Discussion Leader: A. B. Watts

(As an introduction to this subject, Mr. N. W. Flodin, of the Research Division, Electrochemicals Department, E. I. duPont de Nemours and Company, Wilmington, Delaware, presented the following paper on "The Use of Amino Acids in Improving the Nutritional Efficiency of Proteins.")

Flodin

It is well known that proteins differ in the efficiency with which they promote the growth of young animals. One way of measuring protein efficiency is to feed the protein to young rats at a standard level and determine the ratio of body weight gained to weight of protein consumed. On this basis, proteins of high nutritive efficiency are found to have values of about 3 or somewhat higher for the quotient: weight gained/weight protein consumed. These are frequently called "high quality", "first class" or "grade A" proteins. Low efficiency proteins, such as those in whole grains, have quotients usually in the neighborhood of 1-2.

Figure 1

AMINO ACID DISTRIBUTION PATTERNS OF HIGH EFFICIENCY PROTEINS

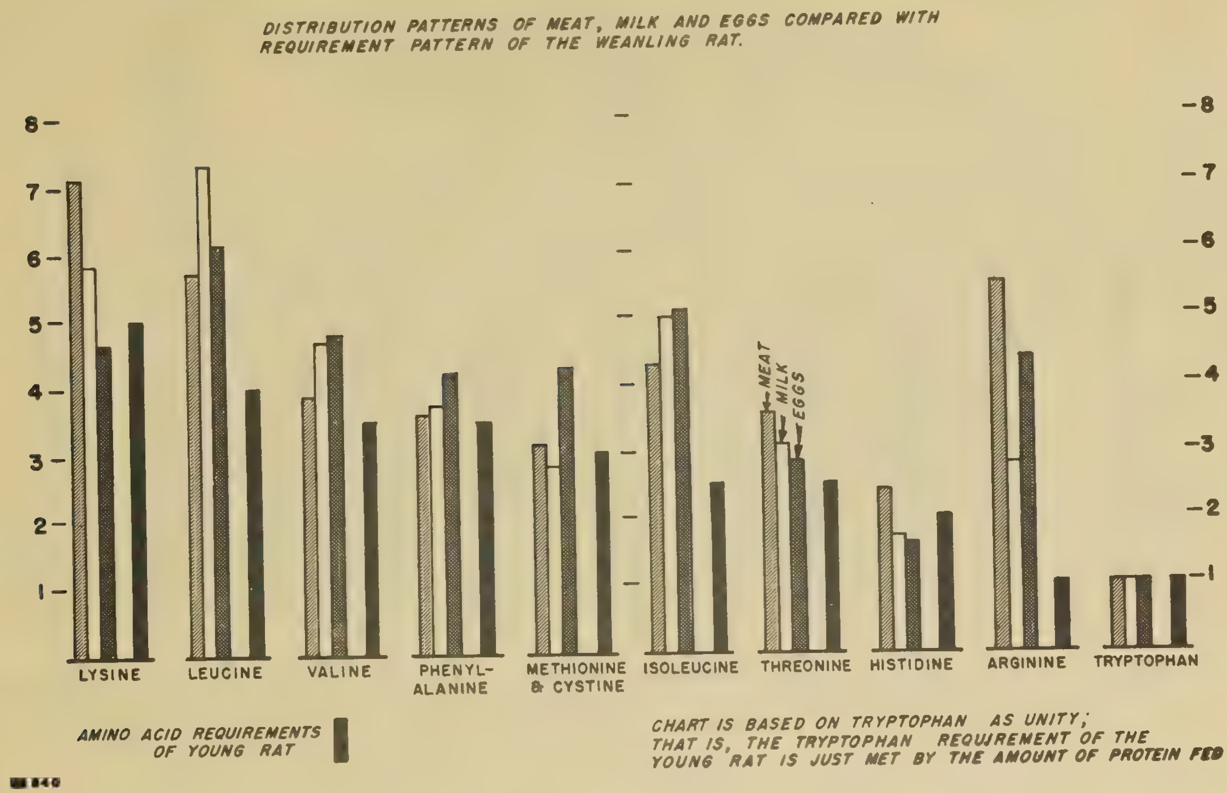


Figure 2.

AMINO ACID DISTRIBUTION PATTERN OF SOYBEAN MEAL PROTEIN

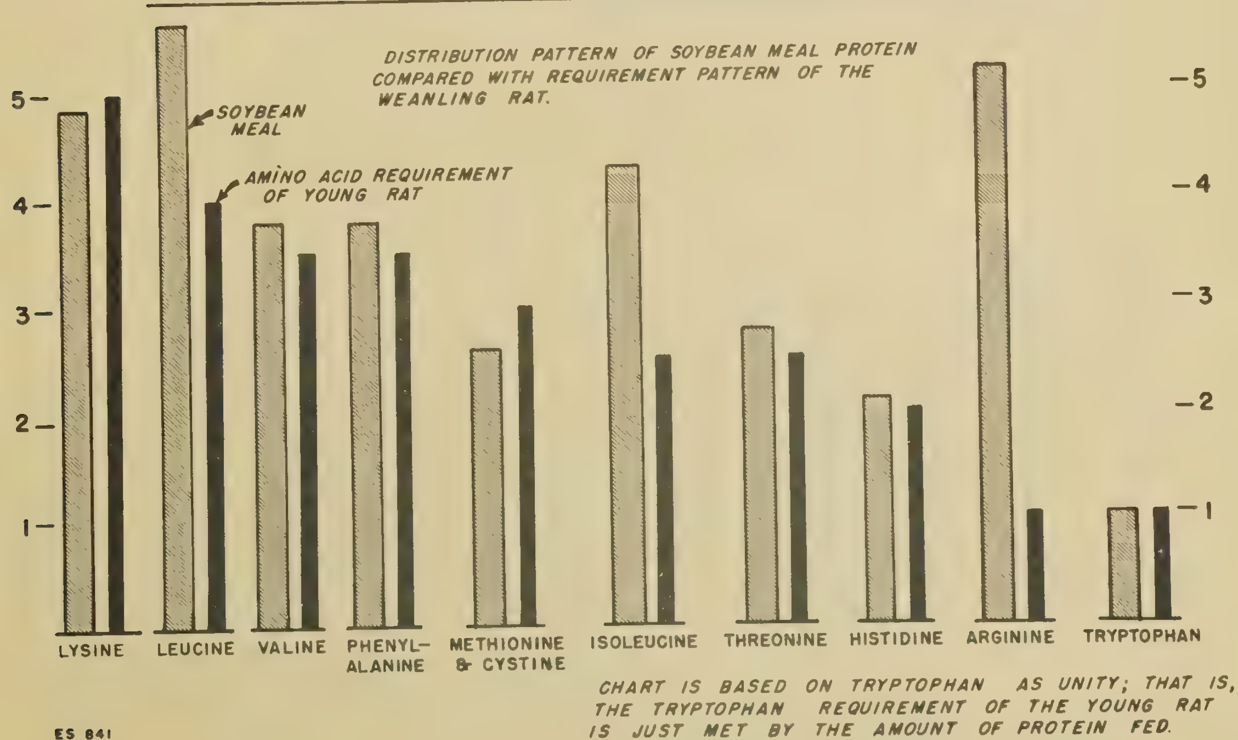
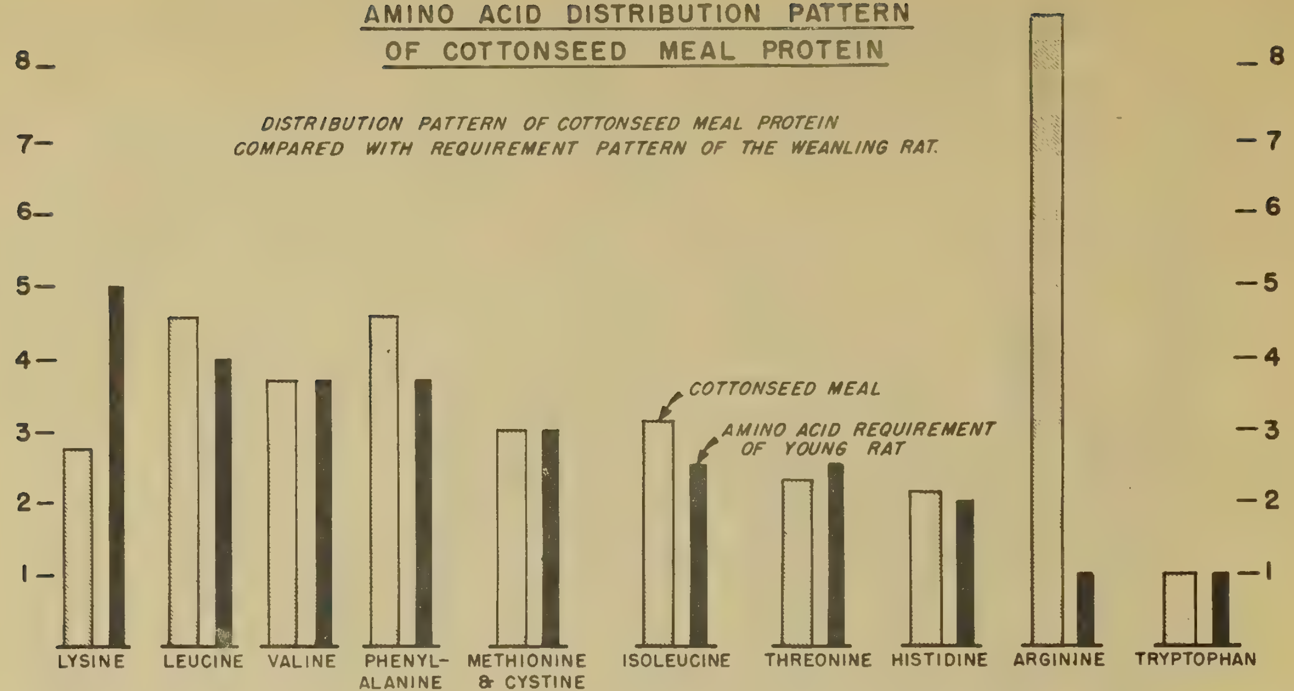


Figure 3.

AMINO ACID DISTRIBUTION PATTERN OF COTTONSEED MEAL PROTEIN

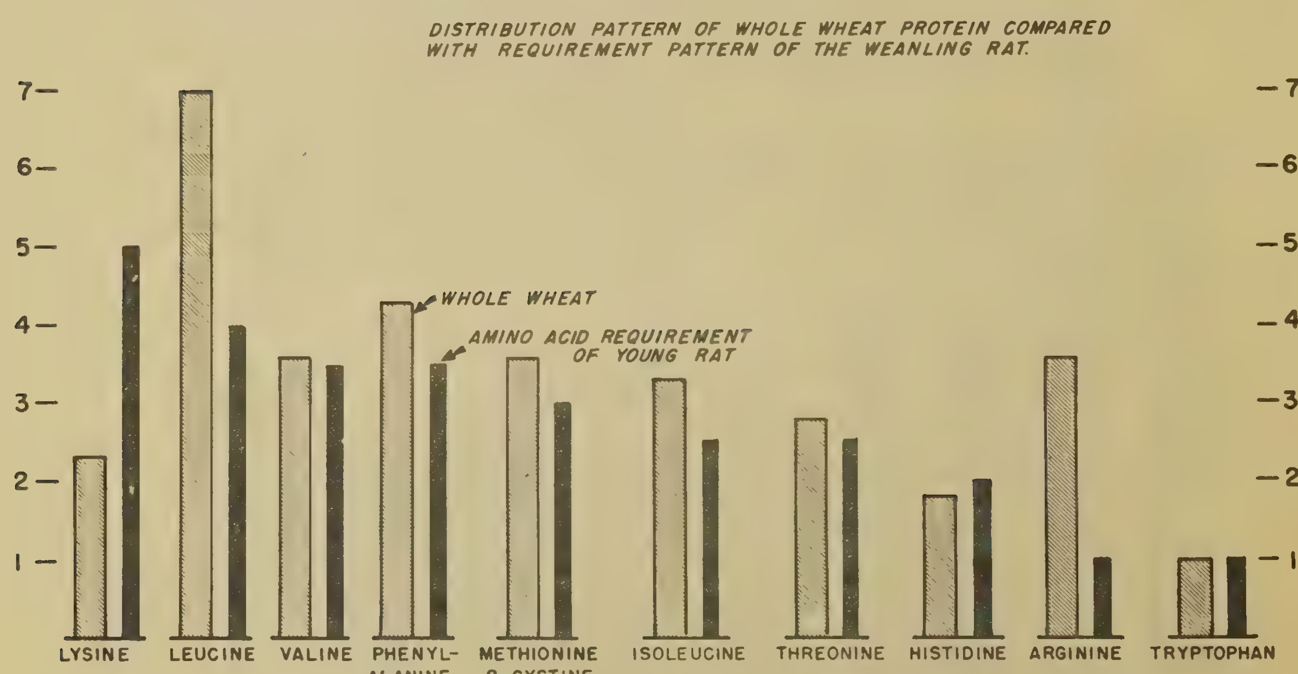


ES 842

CHART IS BASED ON TRYPTOPHAN AS UNITY; THAT IS, THE TRYPTOPHAN REQUIREMENT OF THE YOUNG RAT IS JUST MET BY THE AMOUNT OF PROTEIN FED.

Figure 4.

AMINO ACID DISTRIBUTION PATTERN OF WHOLE WHEAT PROTEIN



ES 843

CHART IS BASED ON TRYPTOPHAN AS UNITY; THAT IS, THE TRYPTOPHAN REQUIREMENT OF THE YOUNG RAT IS JUST MET BY THE AMOUNT OF PROTEIN FED.

Figure 5.

AMINO ACID DISTRIBUTION PATTERN OF WHOLE OATS PROTEIN

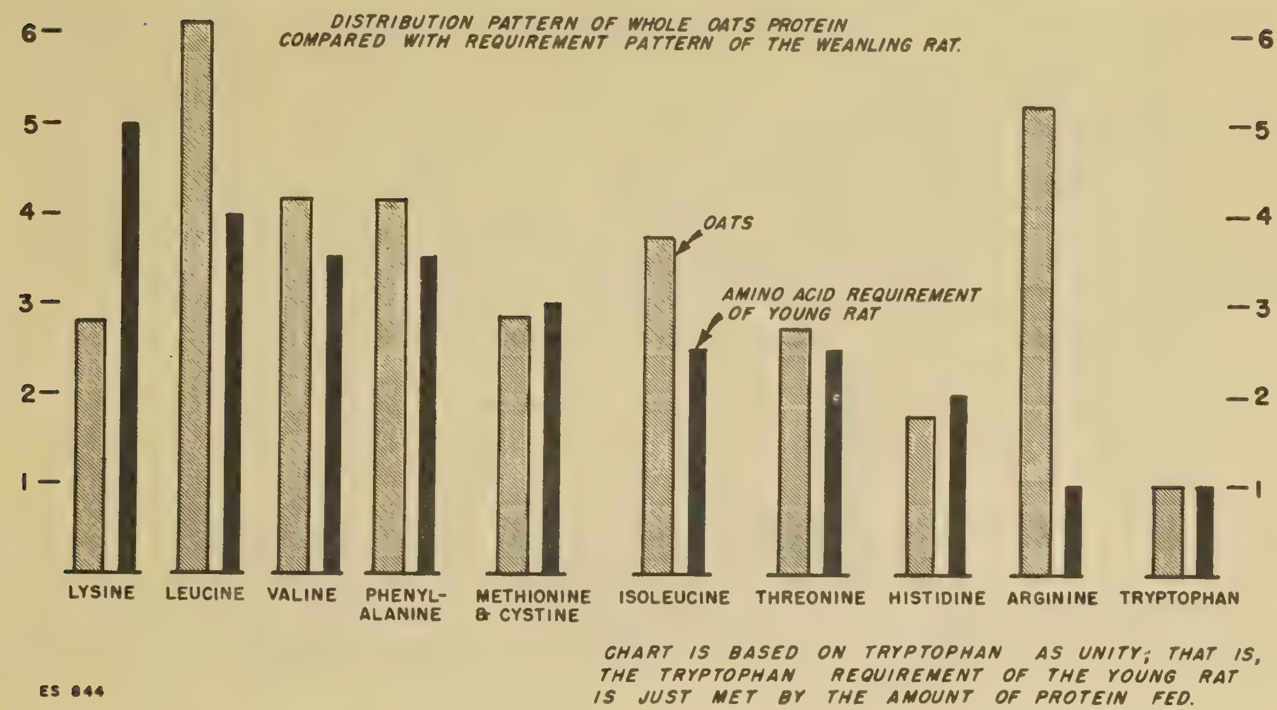


Figure 6.

AMINO ACID DISTRIBUTION PATTERN OF WHOLE CORN PROTEIN

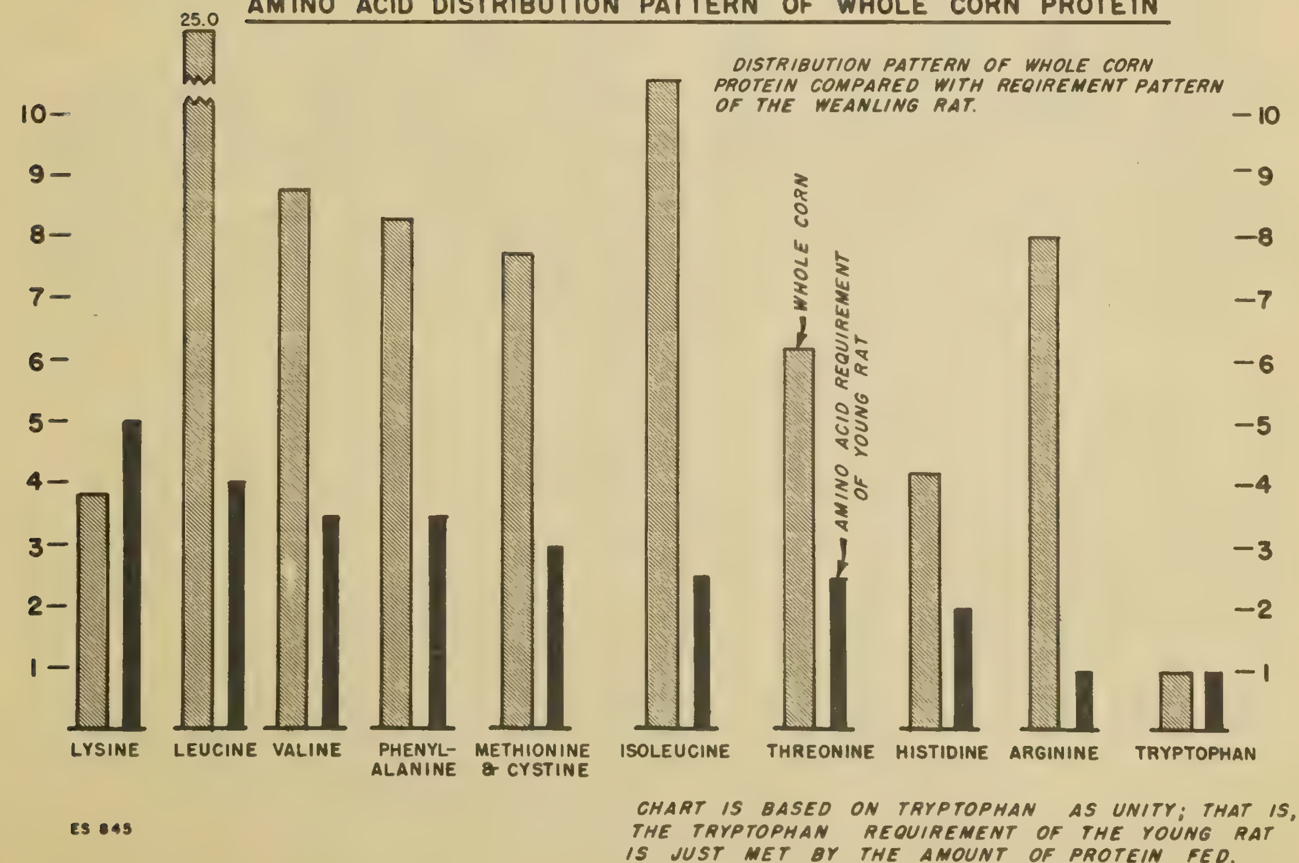


Figure 7

AMINO ACID DISTRIBUTION PATTERN OF WHOLE CORN PROTEIN SUPPLEMENTED WITH LYSINE & TRYPTOPHAN

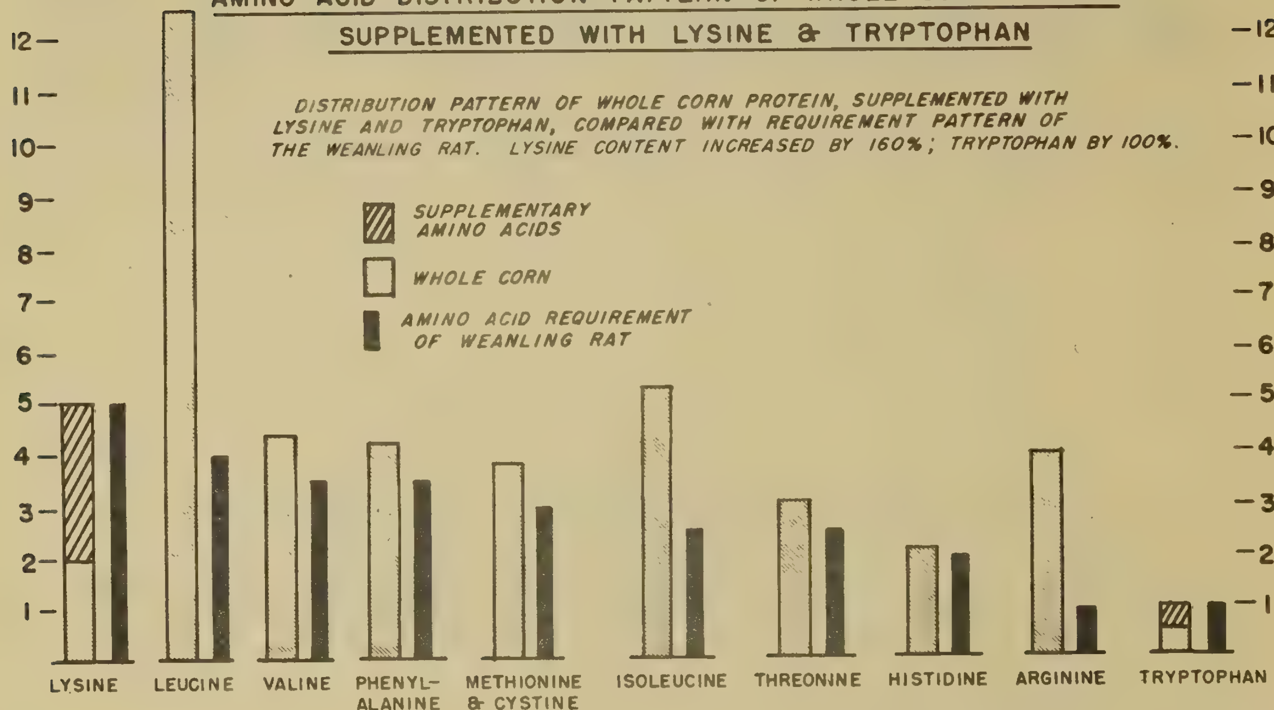


CHART IS BASED ON TRYPTOPHAN AS UNITY; THAT IS, THE TRYPTOPHAN REQUIREMENT OF THE YOUNG RAT IS JUST MET BY THE AMOUNT OF SUPPLEMENTED PROTEIN FED.

ES 846

The reason for differences in nutritive efficiency between various proteins becomes apparent when their contents of essential amino acids are compared with the requirements of the growing animal. This may conveniently be shown in bar graph form by plotting relative amounts of the amino acids as they exist in a given protein and comparing them with the relative amounts required by a typical mammal in the active growth stage, the weanling rat. The work of Beeson at Purdue, Loosli at Cornell, and others indicates that the requirements of the young pig are about the same as those of the young rat. Requirements of the young chick are also similar, with some exceptions to be pointed out later.

To achieve a common denominator, it is assumed that an amount of protein is supplied that contains just the amount of tryptophan required by a representative weanling rat in one day. The weight of any given essential amino acid in that amount of protein, divided by the weight of tryptophan required for one day, gives a ratio or pattern number for that amino acid. This may be plotted alongside a requirement pattern number for the same amino acid, obtained by dividing the young rat's daily requirement for that amino acid by the daily requirement for tryptophan.

Bar graphs have been prepared in this way for a number of high and low efficiency proteins. Analytical data from which these graphs were prepared were taken from Block and Bolling's reference work, "The Amino Acid Contents of Proteins and Foods" (1951 edition). Obviously, the validity of conclusions from graphs of this type depends on the accuracy of recorded data on protein analyses and growth requirements. It is advisable, therefore, to consider only the larger deviations between the distribution patterns of different proteins and the growth requirement pattern.

<u>Figure 1</u> shows the amino acid distribution patterns of three typical high efficiency proteins, compared with the requirement pattern of the weanling rat. The proteins are those of muscle meat, cow's milk and whole egg, all recognized by nutritionists as "high quality" proteins. It will be noted that the various amino acids in these proteins are distributed in such a way as to match closely the requirement pattern for growth. Muscle meat has a distinct surplus of lysine, which explains, as shown later, its value in supplementing low efficiency proteins from grains.

<u>Figure 2</u> gives the amino acid distribution pattern of properly processed soybean meal. The ratio levels of the various amino acids in soy protein match quite closely the levels required by the young rat. Soybean meal provides an excellent protein also for the young chick, whose requirement number for leucine is 6-7 and for arginine is about 5. There appear to be no excesses of any of the amino acids available to remedy deficiencies that exist in other common proteins. The chart indicates that soy protein has a borderline deficiency in sulfur-containing amino acids, a conclusion borne out by recent successes in improving, by addition of methionine, the feed efficiency of broiler feeds based on corn and soybean meal.

Figure 3 shows the amino acid distribution pattern of cottonseed meal protein. Again a remarkably good distribution of amino acids is observed, with one exception. The lysine content is markedly low. This accounts for the relatively low protein efficiency of cottonseed meal. The leucine level in cottonseed meal is somewhat low for the chick, but this amino acid is abundant in the grain components of poultry feeds.

Figures 4 and 5 are the charts for the proteins of whole wheat and whole oats, respectively. Like cottonseed meal, these grain proteins have a pronounced deficiency in lysine, but are well supplied with most of the other essential amino acids. Wheat appears somewhat deficient in arginine for growth of the chick.

Figure 6 gives the distribution pattern for whole corn protein. This pattern is distinctly different from those of wheat and oats. Superficially, the situation with respect to lysine appears relatively favorable. However, note the wasteful excesses in eight of the ten amino acids. The difference between the corn chart and those of the other grains is due to the fact that corn is deficient in tryptophan as well as lysine. If the tryptophan content of corn protein were twice as high as it actually is, the distribution pattern of amino acids in corn would be quite similar to the patterns of the other grains. This is shown in Figure 7, which supposes a 100% increase in the tryptophan level by supplementation. By this means, the distribution pattern of corn protein is made to conform much more closely to the requirement pattern for growth. Leucine is still in considerable excess. The lysine level must be increased by 160%, as shown in the figure, to provide corn protein with the amino acid distribution pattern of a high efficiency protein.

In mixed feeds, as well as in single feeds, highest protein efficiency is achieved when the essential amino acids are present in a distribution pattern corresponding to the animal's requirements. Excesses as well as deficiencies reduce the efficiency. For example, in high efficiency broiler rations based on corn-soybean meal mixtures, about two-thirds of the total protein is commonly supplied by the soybean meal. This soybean fraction, with some methionine supplementation, appears to be almost ideally balanced for chick growth. However, there are no appreciable excesses of amino acids in soy protein, as already discussed, to remedy the deficiencies in the protein supplied by the corn. This situation suggests, therefore, that further improvement in the feed efficiency of corn-soybean meal rations might be achieved through improvement of the corn protein fraction by simultaneous supplementation with lysine and tryptophan. Whether or not this will someday be practical depends, of course, on future developments with respect to the price and availability of these amino acids.

As indicated in the foregoing discussion, the most important amino acid deficiencies known to occur in feedstuffs and animal feeds are in methionine, lysine and tryptophan. The first of these is now being sold in commercial quantities for use in broiler feeds. Suppliers include Dow Chemical Company, E. I. DuPont de Nemours and Company and

U. S. Industrial Chemicals, Inc. These companies provide a synthetic product, the racemic compound, DL-methionine.

Synthetic racemic lysine, in the form of the monohydrochloride, is available for experimental use in nutrition research. Suppliers are Dow Chemical Company and E. I. DuPont de Nemours and Company. Synthetic L-lysine, the naturally occurring optical isomer, is also available in laboratory quantities, supplied as the monohydrochloride by DuPont. L-lysine.HCl derived from proteins can be obtained from Bios Laboratories, Mann Fine Chemicals, Merck and Company and Winthrop-Stearns.

Tryptophan and the other essential amino acids are available in research quantities. They are listed by Bios Laboratories, Dow Chemical Company, Mann Fine Chemicals, Merck and Company and Winthrop-Stearns.

It appears to us in the chemical industry that one of the most valuable types of nutrition research at the present time is the determination of how best to balance the amino acid distribution patterns in the diet to meet the requirements for optimum growth and health, as well as to achieve the most efficient use of our protein resources. In general, the chemical industry stands ready to supply those amino acids for which a real need can be shown to exist and for which the ingenuity of its chemists can provide practical low cost syntheses.

Watts

Two points in connection with the effect of amino acids are important; these are the distribution pattern of the amino acids in cottonseed protein, and the utilization of the amino acids by animals. The level of protein used in feeding tests is important. That is, amino acid requirements are a function of the protein level, and there is an optimum level. When a certain amino acid was added to soybean meal, it actually depressed growth. Lysine has been the critical amino acid involved in most of the studies reported at this conference.

Sex difference, as well as the addition of amino acids to the diet, is very important in protein studies. About 80% of the variations in poultry have sometimes been due to sex differences. The females respond less than the males. In general a mixture of cottonseed and soybean meals was better than soybean meals used alone. The rate of release of different amino acids is a factor in the utilization of proteins.

Lyman

The rate of release is very important if protein is broken down slowly and some amino acids are available more slowly than others, then maybe they are not available for protein synthesis. All amino acids must be liberated and available to the animal at the same time. You

have to feed all amino acids simultaneously. If different acids are fed at different times of the day they will not produce the maximum beneficial effect. How much animals eat also seems to be a factor. Seed proteins containing an excess, or even sufficient, lysine are not found readily; therefore, all the lysine possible must be preserved in processing.

Kuiken

Protein efficiency can be defined as the amount of gain obtained when a given quantity of the protein is fed to an animal. The level at which the protein is fed is a factor in the experiments. Protein efficiency may vary with the amount eaten. The amount fed at one time also is important. A factor to consider is that small amounts may be fed and utilized more efficiently than if large amounts are fed. It is agreed that the level of protein in the test diet should be 10%. Not all researchers agree that the feed intake should be limited, but I believe it should be limited to the amount that the animal with the smallest appetite will take readily. Protein efficiency varies with age, sex, and size of the animals. Bulkiness of feed needs to be considered. Crude fiber content of the feed needs to be adjusted. Also, the fat level in the feed should be adjusted. I believe that animals that have just been weaned should be used and the feeding tests should be carried out for four to six weeks.

Couch

Male chicks gave good response to methionine, but females did not give similar response. 0.05% gives best growth results, Larger amounts depressed the growth rate.

Lyman

Hormones in males and females are different, resulting in different growth rates and different requirements for the sexes. Male birds grow to a larger size, have a higher potential growth rate, and thus require more methionine than females.

Watts

Another point is that standard deviations, standard error, and other statistical factors should be considered for all data. There should be an analysis of the variances.

Now to summarize, we have seen that rations in which cottonseed meal supplies most of the protein are deficient in lysine. The amount of lysine to be added to get maximal growth response needs further investigation. Apparently this will vary considerably with different methods of processing. Kuiken has shown that cottonseed meals heated with oil

containing gossypol will have less available lysine as well as several other amino acids. From a nutritional standpoint the lysine available for growth of the animal is of prime importance, not just the total lysine.

If the amino acid requirements of the animal are a function of the level of protein fed, then it is important that investigations be carried out at protein levels adequate for maximal growth as well as at the low levels necessary for proper evaluation of protein quality. Much additional work is needed where the amino acid deficiencies of the meals are studied at practical protein levels.

From a practical feeding standpoint, it would appear at present that mixtures of soybean meal and cottonseed meal are more advisable than rations containing only cottonseed meal as a protein supplement. In the work reported at this conference, mixtures of soybean meal and cottonseed meal have been superior to cottonseed meal alone.

In experiments to determine the amino acid deficiencies of cottonseed meal, it may be wise to limit the work to chicks of only one sex. If this is not done, data should be reported on the sexes separately as unequal distribution of the sexes would certainly bias the data.

Thus, we see that cottonseed meals of high quality can be produced. They may be somewhat deficient in lysine. Practical rations containing mixtures of cottonseed meals and soybean meal are superior to those containing only cottonseed meal.

***

WHAT IS THE RELATIONSHIP, IF ANY, BETWEEN THE CHEMICAL PROPERTIES AND THE NUTRITIVE VALUE OF COTTONSEED MEALS?

Discussion Leader: C. M. Lyman

Lyman

Studies on the relationships between chemical properties and the nutritive value of cottonseed meals can be divided into two main problems: the problem of gossypol and the problem of protein quality or the nutrients in cottonseed meal. When animal feeding tests are used as a means of evaluating protein quality, the tests must be conducted in ranges where gossypol content has no effect on the growth of the animals. It is well to keep in mind that levels of gossypol too small to produce toxic symptoms may still retard growth.

Experimental methods designed to measure protein quality and other tests which may prove useful in such studies include the following:

1. Direct feeding tests on farm animals.
2. Rat feeding tests, to measure protein efficiencies, protein regeneration, and amino acid availability.
3. Enzymatic digestion (although this does not give complete satisfaction).
4. Tests of protein solubility.
5. Tests of thiamine content.

It is regrettable that data on the thiamine content of test meals has not always been reported along with the growth rates of the animals. In this year's hog feeding tests at the Texas Station, meals which gave the best growth rate had a high thiamine content. These meals also had a high thiamine content. These meals also had high protein solubilities. More extensive comparisons will be necessary before drawing any conclusions as to the general usefulness of thiamine and protein solubility tests for this purpose.

Altschul

My own feeling is that neither thiamine content nor protein solubility provides a reliable index. They are useful within a given series, but not for general application. Cottonseed varies widely with regard to thiamine content.

Electrophoresis investigations have shown differences in the protein components in cottonseed meals, which have been subjected to different degrees of heating.

****

REPORTS ON PROCESSING AND RELATED RESEARCH

GOSSYPOL AND THIAMINE MATERIAL BALANCES IN COMMERCIAL PROCESSING OF COTTONSEED

by
T. H. Hopper
Southern Regional Research Laboratory

An important consideration in improving the nutritive value and in extending the utility of cottonseed meals is the reduction of free gossypol and gossypol-like substances to a low level. Some reason that this must be accomplished before any influence of processing on the biological value of the protein may be evaluated. Newer conceptions indicate that the biological value of the protein is reduced by binding of essential amino acids under the combined influence of moisture, heat, and duration of heating while processing the cottonseed meats for oil and meal. Lacking specific laboratory methods for the estimation of the binding of amino acids, the reduction in thiamine has been investigated as an indicator of the effect of heat. The experience of others in research on soybean processing justified consideration of investigating the reduction of thiamine during the processing of cottonseed.

To obtain information on the material balances for gossypol and gossypol-like substances (hereafter referred to as gossypol) and for thiamine in commercial processing of cottonseed, the cooperation of 5 cotton oil mills was obtained. The type and location of the mills were as follows: Hydraulic, A - West Texas, B - Central Louisiana; and screw press, C - California, D - North Carolina, E - Northwest Mississippi.

Each cooperating mill was requested to obtain composite samples of seed, cooked meats, meal, and oil, each representative of a day's run, at regular two-week intervals, and to forward them to the Southern Regional Research Laboratory. The data are summarized in the following tables, showing the average results of analysis of samples from 9, 8, 11, 2, and 6 composite samplings of mills A, B, C, D, and E, respectively.

Average of Analyses of Mill Samples for Specified Constituents on "As Received" Basis

Mill	Raw meats: Oil	Raw meats: F.F.A. in oil	Oil in meal	Free gossypol: Raw meats	Free gossypol: Cooked meats	Free gossypol: Meal	Free gossypol: Oil
	%	%	%	%	%	%	%
Hydraulic Press							
A	30.4	0.66	5.05	1.06	0.039	0.042	0.033
B	33.8	2.69	4.84	1.08	0.115	0.125	0.094
Screw Press							
C	33.0	1.35	5.42	0.76	0.27	0.038	0.28
D	33.1	1.71	4.70	1.12	0.19	0.033	0.25
E	34.0	2.17	3.76	1.22	0.24	0.048	0.34

Average Thiamine Content and Nitrogen Solubility of Mill Samples

Mill	Thiamine in samples as received: Raw meats	Thiamine in samples as received: Meal	Thiamine in moisture, oil, and hull-free substances: Raw meats	Thiamine in moisture, oil, and hull-free substances: Meal	Thiamine in moisture, oil, and hull-free substances: Reduction	Nitrogen solubility: Meal
	ppm	ppm	ppm	ppm	%	%
Hydraulic Press						
A	20.8	8.4	33.1	12.2	63.0	34.1
B	19.5	14.2	34.4	20.8	39.6	29.0
Screw Press						
C	16.5	4.4	28.1	6.0	78.6	12.7
D	21.8	6.0	38.0	9.2	75.8	11.5
E	18.4	7.1	31.9	10.1	68.4	11.9

Average Gossypol Balances in Mill Samples

Mill	Free gossypol in moisture, oil, and hull-free material: Raw meats	Cooked meats	Meal	Total gossypol per 100 lb. of moisture, oil, and hull-free material: Raw meats	Cooked meats	Meal	Oil	Meal and oil
	%	%	%	lb.	lb.	lb.	lb.	lb.
Hydraulic Press								
A	1.68	0.073	0.063	1.66	1.50	1.47	0.01	1.48
B	1.90	0.23	0.18	1.95	1.90	1.82	0.05	1.87
Screw Press								
C	1.30	0.51	0.052	1.35	1.25	1.03	0.15	1.18
D	1.96	0.40	0.051	1.90	1.72	1.54	0.14	1.68
E	2.11	0.49	0.068	2.14	2.07	1.79	0.21	2.00

The significance of conclusions drawn from these data depends on how representative the cooperating mills are of their type in the cottonseed processing industry.

That hydraulic mill A reduces the free gossypol in the meal to a low level, approximating the level obtained in screw pressing, is of interest. This observation suggests that more attention may be given to the preparation of meats for hydraulic pressing.

Screw-pressed oils appear to contain several times as much gossypol as hydraulic-pressed oils.

The high temperatures developed in screw pressing contributed to a higher reduction in thiamine and nitrogen solubility than was observed for hydraulic pressing.

A relatively small amount of total gossypol is lost in processing cottonseed by either hydraulic or screw pressing. This small loss occurs while the meats are being prepared for pressing. No significant loss attributable to the pressing operations was found.

The processes used by the cooperating mills, as evidenced by the analyses of individual samplings, give confidence that any improved procedures developed for processing cottonseed may be used to produce meals uniformly low in free gossypol without excessive process control.

***

Discussion

Alderks: An excellent presentation and it is in line with our work and findings in connection with screw press operations.

Question: This work will be continued, will it not?

Answer: Yes, the work will be extended. We have to find out more about processing conditions and their effect on cottonseed constituents during processing.

Question: What is the best method for total gossypol determination on cooked material?

Answer: We consider the method developed at this Laboratory by Pons, Hoffpauir, and O'Connor, the most reliable for total gossypol determinations since it shows best results on samples of seed, meats, and meals analyzed across the board. Remember that this method also shows other pigments such as gossypurpurin as gossypol. Reprints of publications describing the method are available.

Question: Is there any difference in the toxicity of the gossypol present in dry-processed material as compared to that in wet-processed material?

Answer: Type of binding of gossypol may differ with different processing conditions, but I cannot fully answer the question based on experience to date.

Question: Is the present method of nitrogen solubility as reliable an index of nutritive value, or damage to protein during processing, as would be an enzimatic digestion?

Answer: Each test used for nitrogen or protein solubility is an empirical procedure designed to fit some particular need. In some cases heating is not necessary to denature protein. There is no evidence of enzymes in cottonseed which would interefere with digestion.

Karon: We did some work on enzymatic digestion. The results are not such that they can be used as reliably as the present nitrogen solubility method. Perhaps our choice of an enzyme was not too good since it did not differentiate between normal and denatured protein.

PRODUCTION OF SCREW PRESS MEALS OF SUPERIOR NUTRITIVE VALUE IN COMMERCIAL OIL MILLS

by
F. H. Thurber and Henry L. E. Vix *

Previous discussions have emphasized that the dietary value of cottonseed meal is dependent chiefly on the protein content, the kind and availability of amino acids in the protein, and on the amount of such components as gossypol that inhibit the growth of animals. Also, it is known that the nutritive value of vegetable proteins is lowered by excessive heating, especially by moist heat under the conditions often used in the commercial cooking of cottonseed meats. Consequently, our objectives in the production of cottonseed meal should be to remove or inactivate the gossypol and gossypol derivatives with the use of excessive heat that would lower the nutritive value of the protein.

At the same time we must keep in mind that cottonseed oil is of more value than the meal, hence modified processing procedures would not be acceptable to industry if the quality of the oil were lowered thereby.

Up to the present time, 9 different series of meals have been prepared by screw press mills in cooperation with the Southern Regional Research Laboratory. Six of these were made by the South Texas Cotton Oil Company and three by the Western Cottonoil Company. The meats going to the cooker varied from almost whole meats to uniformly rolled flakes. The moisture content of the meats varied from about 12% to 6 or 7%, the temperature in the cooker from 160 to 280° F., and the time in the cooker from about 20 to 90 minutes. In the beginning the plan was to make up the meals under specified conditions and then analyze them after samples had been shipped back to the laboratory. In making the last two runs, however, laboratory equipment was taken to the mills where moisture, free gossypol, soluble nitrogen, and lipides determinations were made to aid in determining the type of meal produced.

Our first objective in the preparation of these meals was to determine whether variations in processing conditions really did affect the dietary value of the meals. Nutritional studies that have been reported proved definitely that such is the case. Meals in which the cooking temperatures were 200° F. had a much higher dietary value than those cooked at 240°, and the 240° meals were much better than those cooked at 280°. In the past it has been recommended that not more than about 10% of cottonseed meal be used in the diets of chickens and swine, whereas the experimentally-prepared screw-press meals cooked at 200° or less and containing not more than 0.03% free gossypol were fed to chickens and swine in almost unlimited quantities and excellent growth rates were obtained with both when the diet contained as much as 30% of the screw press meal. Thus the first objective has been attained, but there is much more to be accomplished.

---

* Presented jointly.

We are, of course, defining free gossypol as that part of the gossypol-like pigments extractable with aqueous acetone, total gossypol as that extractable with oxalic acid and aqueous methyl ethyl ketone under the conditions outlined in the method for the determination of these products, and bound gossypol as total gossypol minus free gossypol. In a bound form, it seems to be fairly well established by nutritional studies, gossypol is not toxic to farm animals.

In low temperature (about 200° F.) cooking the best results, from the standpoint of press operations, were obtained when the meats were uniformly flaked to insure uniform conditioning in the cooker and when the moisture content in the flaked meats going to screw press was low enough to yield a cake containing approximately 4% or less of moisture. When moisture content was high it was difficult to maintain a high pressure in some of the screw presses as measured by the energy input to the press, and the meals had both a high oil content and a high free gossypol content. When the time comes for all of the industry to produce meals of high dietary value it may be that the screw press mills will use low temperature, dry-cooking (conditioning) procedures unless better procedures are developed before that time.

Low-temperature dry cooking brings about essentially a reduction in moisture content of the flaked meats, and practically little actual cooking since the glands containing gossypol and other pigments are not greatly changed in the cooker. In the screw press, however, they are ruptured by the pressure and shearing forces. Most of the gossypol from the ruptured pigment glands is combined with other components of the meal to form bound gossypol while the remainder is dissolved in the oil flowing from the press. However, there is less bound gossypol (0.60-0.65%) in the meal from low temperature processing than that (0.80-0.85%) from high temperature processing. This results in a gossypol-like content in the crude oil from low temperature processing as high as 1%, compared with 0.3-0.4% in the oil from high temperature processing.

When the oils with high gossypol-like content from low temperature (200° F.) processing were refined and bleached immediately, an excellent grade of oil resulted; but on storage, particularly at 95° F., for several weeks before refining excessive color reversion took place and the color of the oil was increased. Other problems with modified screw pressing operations using low temperatures were productive capacity and an increase in foots, particularly of a fine nature.

Suggestions from oil mill officials and our own research work, indicate that the problem of drastic color reversion in the crude oil produced by low temperature screw pressing operations might be solved by: (1) immediate cooling of the oil, followed by immediate refining; (2) chemically inactivating the gossypol and other pigments in the crude oil immediately after screw pressing; (3) development of more efficient bleaching operations, rebleaching, high shear bleaching; and (4) production of a screw press oil initially with an extremely low free gossypol-like content (0.03-0.04%) comparable to that of normal hydraulic oil.

On this last approach some mill scale, cooperative work is underway; and results to date show promise, particularly in preparing a screw pressed meal with a free gossypol content of 0.03% or less, and at the same time a screw press oil, closely resembling hydraulic press oil, in that it does not revert appreciably upon storage at 95-100° F. These results are achieved by subjecting moistened cottonseed meats to a careful rolling operation, followed by a modified hydraulic cooking, then cooling the cooked flakes to approximately 180° F., before screw pressing operations. Such operations also result in less foots in the oil compared to that in the oils from low temperature dry cooking and even normal high temperature cooking operations. Productive capacity of such operations was somewhat less than that for normal conventional screw press processing.

A large number of oil mills are being converted to prepressing solvent extraction plants. In these mills, as well as in screw-pressing, hydraulic pressing and solvent extraction plants in which hexane is used as the solvent, it is essential to find ways to lower the free gossypol content of the meal.

Excellent research is being conducted by commercial oil mills along this line. In addition, three investigations are under way in the SRRL to improve the processing of cottonseed meat by all methods. One of these is to find equipment other than the screw press for breaking pigment glands, another is to find cooking conditions which will aid in breaking pigment glands and which will allow the gossypol to combine with other components of the meal without appreciably lowering the nutritive value of the protein, and a third is to find chemicals that will break pigment glands and form stable nontoxic compounds with gossypol. Experimental meals are being produced in the laboratory and pilot plant and are being submitted for nutritional studies, as rapidly as they become available, to determine the nutritive value of the protein and for further studies on the influence of free and bound gossypol on the dietary value of the meal.

***

Discussion

Question: Does the end product meal from straight expeller processing contain less free gossypol than expeller meal prepressed for solvent extraction?

Answer: Yes, that is correct due to a less severe shearing action on the meal during pressing for subsequent solvent extraction.

Question: Do you have gossypol data to show these differences?

Dunning: Pre-press cakes range from 0.1 to 0.15% free gossypol, compared with 0.04 to 0.06% in extracted cakes.

Question: This work emphasizes the necessity of more control in rolling?

Answer: Yes. Just what you have to do to get the gossypol down is important. Data should be available, but if it is not conclusive we will see what we can do about it at this Laboratory.

Dunning: There has been little discussion on the effect of moisture upon gossypol reduction. We have found that high moisture gives better reduction.

Vix: Both moisture and rolling are necessary to effect gossypol reduction.

Question: What were the free fatty acids of the seed and oil discussed?

Answer: In the neighborhood of 0.9 for the seed, and in the oil between 1.4 and 1.5.

Question: Isn't that an excessive increase in free fatty acid?

Vix: Yes, but perhaps I can explain it. Gossypol shows up in the free fatty acid determination as free fatty acid, and the gossypol was high in this particular oil.

Question: Would identical processing of two lots of seed, one having high gossypol and high protein content, and one of low gossypol and low protein content result in production of meals having the same gossypol and the same protein, or possibly would the one having the higher initial gossypol content come out after processing with the lower gossypol content of the two considered?

Gastrock: I think you will have to try that.

***

EFFECT OF CONDITIONS OF ROLLING ON THE CHEMICAL PROPERTIES OF HYDRAULIC PRESSED COTTONSEED MEAL

by
C. G. Reuther, Jr., D. M. Batson, M. F. H. LeBlanc, Jr., and N. B. Knoepfler (NCPA Fellow) *
Southern Regional Research Laboratory

Studies were undertaken at this Laboratory to improve the nutritive value of hydraulic-pressed and solvent-extracted cottonseed meal.

Recent work has shown that it is possible to prepare cottonseed meals of higher nutritive value than those normally produced by pressing mildly cooked meats through a commercial screw press maintained at a relatively moderate temperature. Chemical analyses of the products from this modified procedure showed that the meal was very low in free gossypol content (0.03%) and high in soluble nitrogen (35%). The mild cooking accomplished little gossypol reduction in the meats, but practically complete reduction took place in the press. The reduction during pressing was brought about by the shearing forces causing breakage of the gland walls, thus allowing the pigments either to combine with protein constituents of the meal or to flow out with the oil. Analyses of the oil showed that the latter was predominant.

If it were possible to break a substantial portion of the gland walls in cottonseed meats prior to cooking, the extent of cooking could then be reduced to that necessary to (1) break the remainder of the gland walls; (2) react all released pigments to form bound gossypol; (3) condition meats for best oil expression. The reduced cooking would result in meals of higher nitrogen solubility. Thus this procedure would result in meals similar in chemical analyses to those produced by the modified screw pressing method and the oil would contain much less pigments. In addition, the procedure would be applicable to any method of oil expressing.

Since ordinary flaking operations break a small proportion of pigment glands, attention was directed toward the use of three types of conventional rolls to rupture glands. The present study was undertaken to determine the effect of different rolling treatments upon the pigment glands in cottonseed meats.

In addition, once the rolling effects had been determined, flaked meats with little gland breakage and flaked meats with substantial gland breakage were cooked under various conditions and hydraulic pressed to determine the extent to which gland breakage is responsible for reduction of gossypol in processed cottonseed meal.

---

* Paper presented by C. G. Reuther, Jr.

The results of the rolling study showed that 5-high rolls were better than single corrugated or smooth rolls for causing gland breakage. The effectiveness of all three types was increased as the roll spacings were decreased. Also, each type roll exhibited a critical moisture level necessary in the meats below which few glands were broken. In the case of the 5-high rolls, with maximum spring load and close settings, approximately 55% of the glands were broken when the meats were over 10% moisture during rolling.

Upon completion of the rolling study, two sets of conditions were selected which gave rolled meats as similar as possible except for the amount of glands broken in each. The first set of conditions was smooth rolls set at 0.005" with meats at 14% moisture. The flakes produced had approximately 5% broken glands. The second set of conditions was 5-high rolls set at maximum spring load and close settings with meats at 14% moisture. The flakes produced had approximately 55% broken glands. The two kinds of flakes were cooked in a 5-high cooker and hydraulically pressed in paired runs of identical cooking and pressing conditions. Thus, the differences in free gossypol content and nitrogen solubility noted in the press cakes were due to the differences in degree of gland breakage in the meats caused by rolling. Four sets of paired runs were made using different cooking conditions. The analyses of the press cakes are shown in the following table. Odd numbered runs were made with the smooth rolled flakes and even numbered runs were made with the 5-high rolled flakes.

These data show that under all cooking conditions investigated the 5-high rolled flakes (55% broken glands) resulted in press cakes approximately 50% lower in free gossypol content than the identically cooked meats from the smooth rolled flakes (5% broken glands).

Free-Gossypol Content and Nitrogen Solubility of Press Cakes

Run No.	Free-Gossypol Content %	Nitrogen Solubility %
1	0.33	61
2	0.21	58
3	0.19	53
4	0.07	53
5	0.18	48
6	0.08	47
7	0.09	43
8	0.03	41

Discussion

Question: Was the nitrogen solubility the same on flakes having 5% of the glands broken as it was on flakes having 55% of the glands broken?

Answer: Yes, there was only a slight difference. Figures given were averages. Actual nitrogen solubilities in four tests were as follows:

Test No.	Percent Soluble Nitrogen With 5% gland breakage	With 55% gland breakage
	%	%
1	61	58
2	54	54
3	47	48
4	42	46

Probably the order of feeding the material to the cooker could account for the differences between the 5% and 55%. The order of cooking was varied in as much as the 5% gland ruptured meal was fed first in some cases and the 55% gland ruptured meal in others. Charges to the cooker were made batch-wise and not continuously.

Question: Thiamine values. Are they available?

Answer: Yes, but I do not have them with me. Mr. LeBlanc, do you have them?

LeBlanc: Yes. I have the values for the two meals from the last run. The 5% gland breakage meal had a 17.91 p.p.m. while the 55% gland breakage meal had a 15.36 p.p.m. thiamine value.

Question: Can you give us average flake thicknesses under the various conditions.

Answer: The material should have been the same except for the amount of gland breakage; however, that is not exactly so. Using the smooth rolls with material entering at 14% moisture, and the rolls set at 0.005" clearance, gave an average flake thickness of 0.010" while material entering the 5-high rolls at 14% moisture, with the roll spacings from top down 0.026, 0.015, 0.008, and 0.003" resulted in a shredded material with no definite flake formation. It can be assumed that any differences in gossypol content may be due to particle sizes as well as gland breakage.

Question: What moisture was used in cooking?

Answer: The meats had 14% moisture entering the cooker. The material in the first run was dried down to 7% moisture leaving the cooker, all vents being open and the blower on. It was a drying stage throughout. In the second run the top vent was closed to avoid a drop in moisture in this stage. The balance of the vents were open. The final moisture was again 7%. In the third run the top two vents were closed, thus maintaining the 14% (approximately) in the top two rings. The drying stage was in the bottom ring. The final moisture was again 7% from the cooker. In the fourth run material at 14% moisture was fed to the cooker. Low quality steam was added to bring the moisture content up to 19.6%. The material was dried down to 12% throughout the balance of the cooking operation.

Question: What was the variation in thiamine from run to run?

Answer: Thiamine was determined only on meals approaching the desired 0.03% free gossypol content which we were trying to produce.

Vix: What happens in the first ring of the cooker is most important.

Reuther: Yes. In the last run as the meal left the first ring its gossypol content was down to 0.06% and after leaving the second ring it was 0.03% and the final meal produced from the cooker was 0.026% free gossypol.

***

SCREW PRESSING OF COTTONSEED *

by
A. Cecil Wamble
Texas Engineering Experiment Station

About a year ago a three way agreement was completed between the U. S. Department of Agriculture working through the Southern Regional Research Laboratory, the Cen-Tex Cooperative Oil Mill of Thorndale, Texas, and the Texas Engineering Experiment Station under which it was agreed that the Texas Engineering Experiment Station through its Cottonseed Products Research Laboratory would plan and conduct a research program

---

* A report of work done under a contract between the Texas Engineering Experiment Station and the U. S. Department of Agriculture and authorized by the Research and Marketing Act. The contract is being supervised by the Southern Regional Research Laboratory of the Bureau of Agricultural and Industrial Chemistry.

on screw pressing of cottonseed. This program was to be carried out under controlled conditions, including full scaled operations in a manner applicable to commercial practice to determine:

A. The effect of processing rates and conditions on:
   1. The yield of oil calculated on a refined oil basis.
   2. The amount of operating power required, cost of maintenance and other factors deemed advisable.
   3. The free fatty acid content of the expressed oil and residual oil of the cake; the protein content of the cake; such other characteristics of oil and cake as may reasonably require investigation.
   4. The amount and value of tank bottoms, "foots" and soap stock produced.
   5. The qualitative nature of the components of the screw-pressed oil.

B. To what extent, if any, the use of high moisture seed accentuates the effect of high temperatures of screw pressing on the color and quality of the oil and meal produced.

C. The effectiveness of present methods of cooling screw pressed oils and how they may be improved.

D. The degree of permanent color damage in screw pressed oils and whether this damage can be reduced or eliminated by prompt refining or by other means.

Following the completion of the experimental operation and the evaluation of the end products and reconciliation of the data, recommended standards of operation of screw press mills for processing cottonseed will be prepared.

Actual experimental work at the Thorndale plant started last spring; however, a seed house fire which destroyed the mill's seed stock caused the work to be delayed until the beginning of the present crushing season. All of the runs made this season have been under the same rolling conditions, cooking time, screw speed, and as nearly the same load on the screw press motor as possible. Future plans will include runs at other levels for each of the above conditions. For example, the speed of the crushing rolls will be increased 50% and a series of runs will be made on thinner rolled meats. Later moisture will be added ahead of the rolls instead of in the top ring of the cooker. It is expected that these two changes will tend to produce cottonseed meals of lower free gossypol content. The basis for expecting lower gossypol meal under conditions of thinner rolling and higher moisture content in the meats prior to rolling is a study previously made on rolling conditions. A part of the data from this project to date are not complete enough to form the basis of many hard and fast conclusions. Actually most of it represents runs which would not be expected to produce the type of cottonseed meal which has been found to have superior nutritional qualities of this group.

Probably partly because the conditions are out of the usual operating range of commercial cottonseed processing plants and few plants have had much experience with them, the particular conditions which have been found to produce the best meals from a nutritional point of view are the most difficult to control. This difficulty is not always recognized from reports on the experiments alone. In order to more clearly indicate the nature of the problem the following reasons given by the men actually operating the machines for not cooking at 215° F. final cooking temperature have been listed in approximate order of operator's dislike for them:

Reasons for not cooking at 215° F.

1. The quantity of foots produced is usually greater and the nature of the foots is such that they are difficult to filter.
2. Throughput is low due partly to the screw not taking the feed uniformly.
3. Power is usually very irregular probably due to irregular loading of the screw.
4. It is difficult to get sufficient cooking and low enough final moisture in cooked meats.

The limited data obtained so far does indicate several probabilities:

1. The meals produced at low cooking temperatures which should produce more digestible proteins usually run lower in free gossypol.
2. The best operating conditions for the range covered seems to be at 245° cooking temperature, 300/1000-inch cake thickness and probably at 270° cage temperature. These conditions would not be expected to produce the highest quality proteins.
3. The method of preparation of cottonseed meats prior to screw pressing is expected to be an important factor contributing to the free gossypol content of the cake.
4. The greatest single cause for higher than normal color in freshly pressed screw pressed oils has been shown to be due to leakage of very small quantities of gear compound into the oil.

***

Discussion

Question: Do you have data on the bleach colors of the oils produced in your runs?

Answer: Yes. Some oils have bleached as low as 1.0 Red. Fresh oils bleached better than stored oils. A typical run shows a refined color of 4.62 Red and a bleached color of 1.40 Red.

Question: Did the bleach colors vary as much as the refined oil colors?

Answer: Yes. I would say they did. However, the data are not completely reliable because of their preliminary nature. Additional data may show definite trends. We can offer no explanation for the variation at this time.

Alderks: The tendency in the past has been to report only refined colors, while bleach colors are those of importance. No one eats refined oil.

Wamble: We run bleach colors on all samples, using the photometric method, of the American Oil Chemists' Society.

***

EFFECT OF PROCESSING CONDITIONS ON THE COLOR OF COTTONSEED OIL

by
Catherine H. Pominski
Southern Regional Research Laboratory

The pigments of cottonseed occur in pigment glands that are distributed throughout the cottonseed, a situation unique to cottonseed. New pigments other than gossypol have been discovered in cottonseed. There is considerable variation in pigmentation among different cottonseeds giving rise to variation in the pigmentation of cottonseed products obtained in different localities.

There are a number of methods for the determination of gossypol in cottonseed oil, most of which measure other pigments in addition to gossypol. There is a need for a new method which will measure only gossypol and will be easy to use.

Several samples of crude hydraulic-pressed and screw-pressed oils produced under known processing conditions have been found to differ markedly from each other with respect to their original colors and refining characteristics. Screw-pressed crude oils were more deeply colored and contained one principal pigment, whereas the hydraulic-pressed oils contained two principal pigments. The crude oil pigments differ from gossypol, but like gossypol are removed during alkali-refining. The pigmentation of the crude oils has been shown to depend principally upon the pigmentation of the original seed and the moisture content of the seed during cooking. On the basis of their absorption spectra it has been deduced that the alkali-refined hydraulic-pressed oils contain two to three pigments originally present in the crude oils, whereas the alkali-refined screw-pressed oils contain these same pigments as well as a large number of decomposition products of the principal crude oil pigment. None of these oils exhibit characteristic absorption in the Red region.

In a second series of mill-scale tests involving hydraulic- and screw-press operation, the rate of increase of bleach color in the oils during storage of the seed and crude oil has been correlated with temperature of storage and changes in the absorption spectra of the oils.

In another series of tests designed to determine if variation of the processing conditions prior to screw-pressing would not produce an oil of comparable color and storage quality to hydraulic-pressed oils, the effect of variation in moisture content, temperature and time of cooking as well as method of preparation of the meats has been studied. Results indicate that a lower temperature of cooking for a longer period of time gives the best results, an oil comparable to hydraulic-pressed oil. At this time the meal produced under these conditions has been found to have a higher nutritional value than meals produced under any other conditions of hydraulic- or screw-pressing. This has led to a further series of investigations which has emphasized the nutritional value of the meals produced rather than quality of oil produced. However, in the last series of mill-scale tests, the color of some of the oils obtained by low temperature cooking prior to screw-pressing has been studied to some extent. The color of these oils, as initially produced, compared favorably with those produced by normal screw-press operations. Due to insufficient information it has not been possible to predict their storage properties.

Investigations of the pigmentation of screw-press oils from the plains of West Texas, which normally have high red color, have shown these oils, particularly the alkali-refined oils, to possess an unusually large amount of red pigmentation, as determined by absorption spectra.

The results of an extensive study of the absorption spectra and content of gossypol-like pigments of a large number of hydraulic-pressed and screw-pressed oils from different localities show some interesting relationships between the absorption spectra and their refining and bleaching characteristics.

The necessity for further investigations of a fundamental nature on the pigments of cottonseed oil is very important at this time.

***

Discussion

Ward: This subject is quite important to us now since many mills and industrial laboratories are turning more and more to spectrophotometric color determinations and we must know what they mean to properly interpret them.

***

FUNDAMENTALS OF PRODUCTION OF COTTONSEED MEALS OF SUPERIOR NUTRITIVE VALUE

by
A. M. Altschul
Southern Regional Research Laboratory

The past few years have witnessed considerable progress in organized, cooperative research on the relation of nutritive value to the conditions of processing and chemical properties of cottonseed meals. The purpose of this research has been to determine the objectives for which processors should strive in order to produce meals of superior nutritive value. These objectives now appear to be conditions that will maintain the protein as close to the raw state as possible and at the same time will reduce the "free" gossypol to 0.03% or less.

So far the reduction of free gossypol has been accomplished generally by the use of heat in cooking which introduces a conflict between the two objectives. Attaining one seems to be at the expense of the other. Research, then, must show how the best possible compromise can be achieved; that is, by the production of meals of low free gossypol content with a minimum amount of heat, or by the development of an entirely new type of process.

There are three methods currently in use for processing cottonseed--hydraulic pressing, screw-pressing, and solvent-extraction. In hydraulic pressing decorticated cottonseed is flaked, cooked in the presence of water at temperatures above 230° F., formed into cakes, and pressed at approximately 2000 pounds per sq. inch pressure. In screw pressing decorticated cottonseed is cracked or flaked, heated at temperatures ranging up to 230° F. to 240° F., and forced continuously through a screw-press, in which additional heat is generated by friction--temperatures as high as 300° F. being attained. Solvent extraction may be applied directly, in which case cottonseed flakes are extracted with solvent and the oil-free meal is then toasted; or in combination with pre-pressing, where cottonseed meats are cooked, then put through a screw-press to reduce the oil content to approximately 10%, followed by solvent extraction to remove as far as possible the remaining lipids. An examination of what happens to "free" gossypol and protein value during these various processing operations will clarify the nature of the conflict between gossypol-reduction and the retention of protein value.

Gossypol

The fate of the "free" gossypol is shown in the following table:

"Free" Gossypol in Normal Processing Operations

Process	"Free" Gossypol Content: Meats	Cooked meats	Cake from pre-press	Finished cake or meal
	%	%	%	%
Hydraulic	1.0	0.10	-	.08
Screw-press	1.1	.22	-	.03 - .05
Solvent-extracted	.95	.33 1/	-	.29
Pre-press solvent extraction	.95	.25	.08	.027 - .05

1/ Usually uncooked.

Gossypol in the meats is all in the "free," readily extractable, form. Cooking as practiced in the hydraulic press operation reduces the "free" gossypol to values around 0.1% (In some instances, reduction to as low as 0.04% has been noted). Removal of the oil by hydraulic pressing causes little further reduction in "free" gossypol.

Ordinary screw pressing does not cause as much reduction in the "free" gossypol during the cooking operation as is accomplished in the hydraulic press process. The screw press, however, is capable of reducing the free gossypol during the process of oil extraction. Meals have been obtained by screw pressing which contained the minimum amount of "free" gossypol to permit unlimited feeding to hogs and chicks. It is evident that some of the reduction in "free" gossypol takes place by removal with the oil; witness the much greater amount of gossypol in screw press oil than in hydraulic press oil.

Generally, we have found that the "free" gossypol in solvent-extracted meals is higher than in hydraulic meals. In one set of samples from a mill which used pre-pressing followed by solvent extraction, cooking effectively reduced the "free" gossypol content to a value around 0.25%, and passage of the material through a pre-press resulted in a further reduction in "free" gossypol content to a value of approximately 0.08%. Solvent extraction of the pre-pressed cake, and drying, resulted in a further reduction. In some samples from other mills using the process, there was no reduction in "free" gossypol following pre-pressing. Some of the meals that have been produced by this process have had low "free" gossypol contents (0.027%).

Protein

It is difficult as yet to define protein quality by chemical means, but for our purpose we have selected two measurements that are helpful. The first is nitrogen solubility, which is lowered as the protein is heated. The second is the thiamine content, which seems to be lowered when heat is applied to the protein.

The effect of different processing conditions on the retention of protein quality, as indicated by these measurements, is shown in the following table.

Effect of Type of Process on Nitrogen Solubility and Thiamine Content

Type of Process	Nitrogen solubility	Thiamine content
	%	p.p.m.
Solvent extracted	60	24
Pre-press solvent extracted	30 - 60	13 - 28
Hydraulic press	20 - 30	8 - 14
Screw press	7 - 11	4 - 6

If we consider nitrogen solubility and thiamine content to be related to the protein availability of cottonseed meal, we come to the conclusion that usually only one of the two objectives in processing is attained. Either the material has satisfactory protein value, or at least shows no undue protein damage, but has higher than 0.03% "free" gossypol; or the material has been reduced in "free" gossypol content to 0.03% at the expense of the protein solubility and thiamine content.

Experiments in cooperation with several industrial concerns have shown that it is possible to produce a screw-press meal without heating the meats above 200° F. prior to passage through the press. Such screw press meals have a low "free" gossypol content, 0.03% or less, and also show less change in the protein than do normally-produced (cooked or heated to temperatures above 240° prior to passage through the press) screw-press meals. Feeding tests using these meals have indicated that there is indeed an improvement in nutritive value. There are several questions yet to be answered, however. The most important of these is the effect of such processing upon the quality of the oil. Preliminary experiments have indicated that the oil results in approximately the same refining loss, and color, as normally produced screw-press oil if refined immediately. Upon storage, however, the oils produced by the modified screw-press method gave higher bleach colors.

Research is continuing, in cooperation with industry, on the modification of processing conditions during screw pressing to retain the benefits of minimum heating, yield a meal of low "free" gossypol, and an oil that is as good, if not better, than ordinary screw press oil.

<u>A "universal" approach.</u>

Improvement of screw pressing, however, will affect only one segment of the cottonseed industry. Therefore, it is desirable also to develop an approach toward the production of meals of higher nutritive value by hydraulic pressing and the various methods of solvent extraction. Such a "universal" approach may be arrived at by considering the fundamentals of reduction in "free" gossypol. The following chart shows the avenues of change available to "free" gossypol during the processing of cottonseed.

Possible Fate of "Free" Gossypol

PIGMENT GLANDS

↓

"FREE" GOSSYPOL

↙	↙	↓	↘	↘
Bound in Meal	Remains in Meal as "Free" Gossypol	Removed with Oil	Changed by Chemical Reaction	Removed as Intact Glands

Originally all of the gossypol is in cottonseed pigment glands, in what we consider the "free" state. If the pigment glands are ruptured, the gossypol can then take several courses. One course is to bind it with the constituents of the meal, presumably with some of the active groups of the amino acids of the proteins. Under such a condition it remains in the meal but is not readily extractable with aqueous acetone, and is called "bound" gossypol. Nutritional evaluations to date seem to indicate that the limitations in feeding associated with gossypol are related to the "free" gossypol but not to the "bound" gossypol. Another course available to the gossypol liberated from the pigment glands is to dissolve in the solvents used to extract the oil or to be removed in the oil as it is pressed out. A third course is to react with chemicals to form nontoxic products. There is also the possibility of removing the intact pigment glands by "fractionation," but this method has not yet been developed to a practical stage.

Let us consider some of the processes in the light of this knowledge. In a typical hydraulic press operation cooking serves to rupture the pigment glands and liberate the gossypol to react with the other constituents

of the meats, and also accelerates the reaction to result in conversion of most of the "free" gossypol into "bound" gossypol. In screw pressing the pigment glands are ruptured and the heat developed by attrition inside the press promotes the binding of a portion of the gossypol with the meal, while significant quantities are pressed out with the oil.

The difference between screw- and hydraulic-pressing has been attributed to the fact that cottonseed meats are subjected to shear in the barrel of the screw press and that pressure with shear promotes the rupture of pigment glands whereas direct pressure is much less effective. The fact that shear and pressure combined can rupture pigment glands led to the thought that it might be possible to reduce the load on the cooker by rupturing part of the pigment glands mechanically without heat prior to cooking. All that would remain to be accomplished in the cooker would be the rupture of the remaining pigment glands and binding of the "free" gossypol with the meal. The major consideration in cooking would be to prepare the material properly for extraction, whether by pressing or by solvent extraction. Minor attention would have to be paid to the reduction in "free" gossypol at this step. Pilot plant experiments have demonstrated that such a procedure has possibilities--mechanical rupture of pigment glands prior to cooking enabled more effective reduction in "free" gossypol during cooking.

A comparison of processes.

A summary of the progress made in achieving a "compromise" between the reduction in "free" gossypol and the retention of protein value in cottonseed meal is given below:

General Comparison of Cottonseed Meals from Different Processes

Type of Process	Meats requirements on free gossypol 1/	Meats requirements on protein value 2/
Butanone extracted	Yes	Yes
Hydraulic press	No	Yes
Solvent extracted	No	Yes
Pre-press, solvent extracted	No 3/	Yes
Screw press	Yes	No
Low temperature screw press	Yes	Yes 3/
Pilot plant hydraulic press or solvent extraction	Yes 3/	Yes

1/ Contains 0.03% or less "free" gossypol.
2/ Nitrogen solubility above 20%.
3/ Some commercial "pre-press" meals, modified screw-press meals produced on an experimental basis in commercial plants, and some pilot-plant hydraulic meals seem to meet the current qualifications.

It is noteworthy that several attempts have been made to resolve the "conflict" by entirely new approaches. The gland fraction process developed at the Southern Laboratory for the complete removal of gossypol by mechanical means is an example. Another is the removal of gossypol by chemical reaction that is being practiced by the Buckeye Cotton Oil Co. at present.

With the demonstration that meals of improved dietary value can be produced, more attention now must be directed to the effect of modifications in processing on the quality and yield of oil. There is already a much better understanding of the fundamentals of cottonseed processing as a result of our combined research and it is not too much to hope that the processing of cottonseed can be further improved to yield both oil and meal of superior quality.

***

Discussion

None.

***

IMMEDIATE PROCESSING AND ENGINEERING PROBLEMS REQUIRING INVESTIGATION

by
E. A. Gastrock
Southern Regional Research Laboratory

Cottonseed oil has been worth, during the past decade on a weight basis, from 4 to 7 times the value of cottonseed meal; and because of this fact, most processing and engineering research has been directed toward increasing the yield of the oil, and the throughput of the processing plant. Furthermore, since the quality of the oil is defined by trading rules, with a system of premiums and discounts, the yield of oil and throughput cannot be considered wholly apart from oil quality. Oil quality, therefore, has been next in importance as a subject for processing and engineering research because, as in the case of yield and throughput, improvements in oil quality are reflected in increased dollar value of the products.

On the other hand, the meal quality is not as well defined by trading rules nor does the present state of our knowledge of nutrition permit as clear a definition as might be desirable of the nutritive value of cottonseed meal or for that matter, for any protein meal. Thus, research to improve meal quality is lacking the very important incentive of increased monetary return from the improvements made. It should be evident that in improving meal quality any possibility of impairing oil yield, oil quality and productive capacity must be avoided.

These general considerations must be applied in seeking solutions to our processing problems, but each individual case is further affected by the quality of seed processed and the method of processing used; that is, whether by hydraulic or screw pressing, by direct or pre-pressing solvent extraction, or by any new process such as filtration-extraction.

The complexity of the problems should be evident from the foregoing, but I believe the greatest progress can be made by first studying in a most thorough fashion two phases of the processing operations that are common, at least in part, to every one of the processing methods now being used. These two phases are rolling and cooking. Rolling is common to each processing method and if we consider the conditioning of meats in direct extraction as a form of cooking, then we can say that cooking is also common to each processing method. In proposing this thorough study of rolling and cooking I am well aware of and want to pay tribute to related research that has been carried out in the past and to the work that is now underway on these phases. A great amount of know-how regarding rolling and cooking comes to us from hydraulic pressing. In this method of processing almost complete dependence is placed on rolling and cooking in order to obtain press capacity, oil yield and oil quality.

In screw pressing the cookers are used largely as a means of drying the meats to the low percentage of moisture that is necessary if high yields of oil and high press capacity is sought. Cracking and rolling as well as cooking are too often minimized in this method. I believe that inadequate rolling and the use of somewhat dry cooking is responsible for some of the difficulties of this method.

In direct extraction, rolling is done after the meats are conditioned, and thin, strong flakes, with a minimum of fines are sought. One can readily see that the cooking step has serious limitations placed upon it in this method.

I believe that the pre-pressing solvent extraction method has made much of its recent progress because more attention is being directed to the rolling and cooking phases.

In our own research on the filtration-extraction method we consider rolling and cooking of the utmost importance.

Let us consider for a moment what we are trying to accomplish. We start with seed that are, for the most part, alive. After removing linters and hulls we start processing the meats. The meats or kernels plus about 25% hulls, as processed, contain about 30% of oleaginous materials, 5 to 15% of water, 1 or 2% of pigment glands, several percent of sugars, about 30% of protein (which produced a 41% protein cake or meal upon removal of the oil), some crude fiber and other minor constituents. The oleaginous material may contain from 1/2% to 10% or more of free fatty acids. Also present are phosphatides, sterols, and other minor constituents in varying amounts. This mass of meats and hulls is permeated by a number of enzyme systems which are usually kept

in good balance in a good quality of seed, properly stored. But when the hulls are removed and rolling is done, it is like the last day of school. All the different enzyme systems get ideas (bad ones) of their own. What occurs should not happen to a cottonseed.

But most of the trouble is caused by the pigments of the seed--most of which are various related forms of gossypol. When the pigment glands are broken during rolling, cooking, pressing, or by the action of water or other solvents, the gossypol pigments that emerge will remain with the oil unless conditions are present that will cause these pigments to combine with some portion of the meal. Generally speaking, three conditions are encountered:

1. Gossypol that is removed with the oil, will present difficulties in producing oils of prime color;
2. Gossypol that remains in unbroken or partially broken pigment glands or has loosely combined with the meal is measured as free gossypol in the resulting meal and is responsible for the toxic effects; and
3. Gossypol that has firmly combined with the meal is measured as bound gossypol, and is generally considered to be non-toxic.

Some glands may be broken and some gossypol may be found during rolling. Most of the binding can be made to occur during cooking but if the job is only partially done then some binding can occur during screw pressing.

In hydraulic pressing, however, gossypol removed from the pigment glands and not bound during cooking will usually be found in the oil as very little binding occurs in the hydraulic press. If any glands are unbroken or still contain gossypol, they also are but slightly affected by hydraulic pressing, and such gossypol stays in the cake or meal as undesirable, free gossypol.

In pre-pressing solvent extraction pigment glands may be broken and gossypol binding may occur in many of the steps--in the preliminary rolling, in cooking, in pre-pressing, in conditioning and flaking, and to some extent in final meal desolventization. It may also occur in pelleting or briquetting of the meal product.

In direct extraction, however, what usually occurs is that some glands are broken during conditioning and flaking, but very little binding occurs. Consequently enough gossypol is present in the oil to give trouble and considerable free gossypol is present in the meal.

We consider it very fortunate that our filtration-extraction process requires cooking because this not only improves the extraction and the operation of the filter but also gives us a powerful tool to use in improving oil and meal product quality.

To summarize, I believe that a thorough study of rolling and cooking will enable us to find the best conditions for breaking pigment glands and for directing the gossypol pigments in the least troublesome form to the product or products. I am sure that the conditions will vary somewhat for seeds of different quality and for different methods of processing but when the underlying principles are more completely understood and applied, it will be easier to carry out engineering and processing research on the remaining phases of the various methods of processing cottonseed.

***

Discussion

Dunning: What are cooking conditions as distinguished from drying conditions? Can the cooking stage be defined in terms of temperature, time, and moisture content in order to divorce it from the drying stage? We know that at temperatures above 205° F., the vapor pressure of moisture present in the meal prevents the entrance of further moisture into the meal tissues. You can "cook" at 12+% moisture at 215° F. and actually not cook.

Altschul: Drying is the application of heat accompanied by loss of moisture. In organic material, certain other changes also take place. A series of laboratory cooking experiments where the moisture is kept constant, temperature and time being varied, are now being undertaken at this laboratory to show the effect on properties. This may yield some information.

Vix: In some pilot-plant runs we have noted the same effect. With a high moisture (21-25%) in the first ring, a time of 12 minutes, and temperature below 212° F., we get a very rapid reduction of free gossypol with a minimum reduction in nitrogen solubility. For hydraulic press cookings succeeding rings were used for drying with vents open. The problem is to achieve a rapid reduction in free gossypol without appreciably affecting the nitrogen solubility of the material.

Question: Why do hydraulic press operators like to obtain 190° F. in the first ring very quickly?

Fincher: Getting to 120° F. very quickly is necessary to control oil quality and refining losses. Failure to do so gives high refining losses.

Vix: Then the differences observed in our pilot-plant work may be attributed to our feeding of the cooker batch-wise and not continually.

Question: What effect did high temperatures have on oil quality? Noticed low refining loss with low temperature in top ring. Why?

Vix: The seed was dry, 6-7% moisture. Due to the fact that this moisture was low, we stayed out of the danger zone in cooking. Also, did very little work; most work, mainly drying, took place in the last ring in the cooker.

Gastrock: One handicap in these studies has been the lack of adequate instrumentation. We need a method for immediate, accurate, and continual measurement of conditions in each ring of the cooker.

Markley: Again, how do you determine when cooking stops and drying starts?

Dunning: Cooking stopped at 205° F. and drying started. There is no instrument to actually determine this; it is usually best done by a trained operator who feels, smells, and sees. Tests at various mills which related results of oil and meal quality where meal was cooked at over 205° F. in the top ring of a stack cooker have shown feeding difficulties, high foots, high refining losses, and oil color reversion. The critical empirical conditions are: moisture above 12%, temperature below 205° F., time 15 to 17 minutes.

Markley: Protein tanning occurs at temperatures above 205° F. and accounts for the feelability of the material being cooked.

Dunning: Explain why drying at 210°-220° F. in hydraulic cooking does not decrease the protein solubility as it does in prepress operations.

Vix: If originally 100, the protein solubility drops to 80 in the first ring of the cooker at a temperature of 200°-205°, and is not appreciably reduced in the lower rings of the cooker as this is a drying stage operation.

***

CONCLUDING REMARKS

by
A. L. Ward, Director
Educational Service, National Cottonseed Products Association

In closing this important conference, it seems appropriate to say that the cooperative efforts of the Southern Regional Research Laboratory, the experiment stations, and industry are definitely paying off. The attention given to the improvement of cottonseed meal during recent years has provided investigators in the field of nutrition with a basis for greatly enlarged research. They now have a much wider field in which to work.

As evidence of the keen interest that exists in this cooperative research program today, I would like to point to the attendance at this conference. Some of the best men and women in the field of nutritional research are here. Many technical men from within the cottonseed crushing industry also are present, along with the managers and owners of oil mills. In addition, there is a good representation of machinery manufacturers, who share the interest of scientists and of the cottonseed industry in improved methods of processing to produce meals of higher nutritive value.

It is a great satisfaction to see the growing response to this endeavor. The enlarged opportunities for research on the nutritive value of cottonseed meal that have been opened through cooperative research mark great progress. We can now move forward, optimistically, toward significant achievements in the future.

A P P E N D I X

PROGRAM

MONDAY, NOVEMBER 5, 1951 10:00 A.M.

Opening Remarks

C. H. Fisher, Director, Southern Regional Research Laboratory

Reports on Feeding Experiments

F. H. THURBER, Chairman

The Nutritional Value of Screw-Pressed Cottonseed Meal When Fed as the Principal Protein Supplement for Farm Animals
E. L. Stephenson, University of Arkansas

Response of Growing Animals Receiving Diets Containing Cottonseed Meal Prepared by Various Processes
F. H. Smith, North Carolina Experiment Station

Amino Acid Supplementation of Cottonseed Meal Rations for Weanling Pigs
H. D. Wallace, Florida Agricultural Experiment Station

A Comparison of Cottonseed Meal and Soybean Oil Meal in Practical Broiler Rations
Francis H. Bird, Eastern States Farmers' Exchange

The Use of Pre-Pressed Solvent Extracted Cottonseed Meal as a Protein Supplement for Growing Pigs
J. L. Fletcher, Mississippi State College

LUNCH

Reports on Feeding Experiments (Continued) 2:00 P.M.

T. H. HOPPER, Chairman

Buckeye Degossypolized Cottonseed Meal
Kenneth Kuiken, The Buckeye Cotton Oil Company

Various Types of Cottonseed Meals in Rations for Chicks and Laying Hens
C. L. Morgan, South Carolina Agricultural Experiment Station

Pig Feeding Tests with Special Process Cottonseed Meals
C. M. Lyman, Texas Agricultural Experiment Station

Nutritive Value of Cottonseed Meal for Chicks
J. R. Couch, Texas Agricultural Experiment Station

Evaluations of Nutritive Value of Cottonseed Meals as Swine Feeds
N. R. Ellis, Bureau of Animal Industry, USDA

Experiments on Gossypol in Diets for Chickens, and on Pink Discolorations in Eggs Caused by Some Component of Cottonseed
Burt W. Heywang, Southwest Poultry Experiment Station, Bureau of Animal Industry, USDA

Comparison of In Vitro and In Vivo Methods of Protein Evaluation
Madelyn Womack, Bureau of Human Nutrition and Home Economics, USDA

TUESDAY, NOVEMBER 6, 1951 9:30 A.M.

Round Table Discussions of Significant Questions in Nutrition

A. M. ALTSCHUL, Chairman

What are the limits of free gossypol content that affect the value of cottonseed meal in hog and chick feeds?

Discussion Leader........... J. R. Couch, Texas A. & M. College

What are the limits of free gossypol content that affect the use of cottonseed meal in mashes for laying hens?

Discussion Leader........... Francis H. Bird

What is the effect of processing conditions on the protein value for hogs, chicks, and cattle of meals containing .03% or less free gossypol?

Discussion Leader........... N. R. Ellis, Bureau of Animal Industry, USDA

LUNCH

Round Table Discussions (Continued) 2:00 P.M.

What is the effect of supplementing cottonseed meal with amino acids? How do mixtures of cottonseed and soybean meals compare to either used alone?

Introduction: The Use of Amino Acids in Improving Nutritional Efficiency of Proteins...N. W. Flodin, E. I. duPont de Nemours & Co.

Discussion Leader..... A. B. Watts, Louisiana State University

What is the relationship, if any, between the chemical properties and the nutritive value of cottonseed meals?

Discussion Leader........... C. M. Lyman, Texas A. & M. College

Tour of Laboratory and Private Conferences 4:00 P.M.

WEDNESDAY, NOVEMBER 7, 1951 9:30 A.M.

Reports on Processing and Related Research

E. A. GASTROCK, Chairman

Gossypol and Thiamine Material Balances in Commercial Processing of C/S
T. H. Hopper, Southern Regional Research Laboratory

Production of Screw Press Meals of Superior Nutritive Value in Commercial Oil Mills
H. L. E. Vix and F. H. Thurber, Southern Regional Research Lab.

Effect of Conditions of Rolling on the Chemical Properties of Hydraulic Pressed Cottonseed Meal
C. G. Reuther, Southern Regional Research Laboratory

Screw Pressing of Cottonseed
A. C. Wamble, Texas Engineering Experiment Station

Effect of Processing Conditions on the Color of Cottonseed Oil
Catherine H. Pominski, Southern Regional Research Laboratory

LUNCH

Tour of Laboratory and Private Conferences 1:15 P.M.

Reports on Processing and Related Research (Continued) 2:15 P.M.

K. S. MARKLEY, Chairman

Fundamentals of Production of Cottonseed Meals of Superior Nutritive Value
A. M. Altschul, Southern Regional Research Laboratory

Immediate Processing and Engineering Problems Requiring Investigation
E. A. Gastrock, Southern Regional Research Laboratory

Round Table Discussion

Concluding Remarks - A. L. Ward, Director, Educational Service
National Cottonseed Products Association

****

LIST OF ATTENDANCE

Industry

Alderks, O. H., Technical Division, The Buckeye Cotton Oil Co., M. A. & R. Bldg., Ivorydale, Cincinnati 17, Ohio
Bird, Francis H., Eastern States Farmers' Exchange, Inc., R.F.D. 3, Rockville, Conn.
Blyth, Richard H., Pres., Southland Cotton Oil Co., Paris, Texas
Brooks, Tom R., French Oil Mill Machinery Co., Atlanta, Georgia
Brady, Joe C., Helena Cotton Oil Co., Helena, Arkansas
Bryson, J. H., Jr., Dothan Oil Mill Co., Dothan, Alabama
Byram, J. E., Jr., Red River Cotton Oil Co., Inc., Alexandria, La.
Christensen, S. B. L., Dansk Sojakagefabrik, 24 Islands Brygge, Copenhagen, Denmark
Clark, Tom, Red River Cotton Oil Co., Inc., Alexandria, La.
Dillard, E. L., Dothan Oil Mill Co., Dothan, Alabama
Dunning, John W., V. D. Anderson Co., Cleveland, Ohio
Eagle, Edward, Swift & Co., Union Stock Yards, Chicago 9, Illinois
Eberhardt, E. O., Buhler Brothers, Inc., 2121 State Highway #4, Fort Lee, N. J.
Fincher, H. D., Anderson Clayton & Co., Houston, Texas
Flodin, N. W., E. I. duPont deNemours & Co., Inc., Wilmington, Delaware
Freeman, A. C., Dothan Oil Mill Co., Dothan, Alabama
French, A. W., V. P., The French Oil Mill Machinery Co., Piqua, Ohio
Gandy, Dalton E., Educational Service, NCPA, Ruston, Louisiana
Hahn, George, The Buckeye Cotton Oil Co., Atlanta, Georgia
Harper, Garlon A., Educational Service, NCPA, Dallas, Texas
Heidebrecht, A. Allen, Western Cottonoil Co., Abilene, Texas
Houghtlin, R. G., Natl. Soybean Processors Assoc., 3818 Board of Trade Building, Chicago 4, Illinois
Ingold, Robert, Dir., California Cotton Oil Corp., Los Angeles, Calif.
Karnofsky, George, Blaw-Knox Construction Co., P. O. Box 778, Pittsburgh 30, Pa.
Kirkland, Byron A., Educational Service, NCPA, Atlanta, Georgia
Kruse, N. F., Central Soya Co., Inc., Decatur, Indiana
Kuiken, Kenneth, The Buckeye Cotton Oil Co., M. A. & R. Bldg., Ivorydale, Cincinnati 17, Ohio
McKenzie, Emmett, Jr., Central Cotton Oil Co., Macon, Georgia
Mays, J. R., Jr., Barrow-Agee Laboratories, Inc., Memphis 1, Tennessee
Moloney, John F., National Cottonseed Products Association, Inc., Memphis, Tennessee
Moore, Walter B., Educational Service, NCPA, Dallas, Texas
Newby, Wales, Cotton Products Co., Inc., Opelousas, Louisiana
Pascal, W. W., French Oil Mill Machinery Co., Piqua, Ohio
Prince, R. K., Allis Chalmers Manufacturing Co., Milwaukee, Wisconsin
Queroya, Mrs. A., Quinn Menhaden Fisheries, Inc., New Orleans, La.
Quinn, Wallace M., Quinn Menhaden Fisheries, Inc., Empire, La.
Roberts, J. Bob, Proflo Div., Traders Oil Mill Co., Ft. Worth, Texas
Sherman, W. C., Ralston Purina Co., Checkerboard Square, St. Louis 2, Mo.
Smith, Leonard, National Cotton Council of America, Washington, D. C.

Industry (Continued)

Waddell, J., E. I. duPont deNemours & Co., Inc., New Brunswick, N. J.
Wallace, C. W., The Union Oil Mill, Inc., West Monroe, La.
Ward, A. L., Director, Educational Service, NCPA, Dallas 1, Texas
Williams, P. H., South Texas Cotton Oil Co., 2405 Collingsworth, Houston, Texas
Wilson, Logan T., J. T. Gibbons, Inc., 2700 Howard Ave., New Orleans, La.

State Universities and Experiment Stations

Barrentine, Ben F., Animal Husbandry Dept., Mississippi State College, State College, Miss.
Brown, Paul B., Dept. of Animal Industry, La. State University, Baton Rouge, La.
Burns, Moore J., Dept. of Animal Husbandry and Nutrition, Alabama Polytechnic Institute, Auburn, Alabama
Chamberlain, Charles C., Tennessee Agricultural Experiment Station, Knoxville, Tenn.
Couch, J. R. Dept. of Biochemistry and Nutrition, Texas Agricultural Experiment Station, College Station, Texas
Dyer, I. A., Dept. of Animal Husbandry, University of Georgia, Athens, Georgia
Fletcher, J. L., Dept. of Animal Husbandry, Miss. State College, State College, Mississippi
Frye, J. B., Dairy Dept., Louisiana State University, Baton Rouge 3, La.
Gallup, W. D., Oklahoma A. & M. College, Stillwater, Oklahoma
Heywang, Burt W., Southwest Poultry Experiment Station, Rt. 1, Box 80, Glendale, Ariz.
Hickox, G. H., Engineering Experiment Station, University of Tennessee, Knoxville, Tenn.
Holley, K. T., Georgia Agricultural Experiment Station, Experiment, Ga.
Lyman, Carl M., Dept. of Biochemistry and Nutrition, Texas Agricultural Experiment Station, College Station, Texas
McNeice, Denney, Louisiana State University, Baton Rouge, Louisiana
Morgan, C. L., Poultry Dept., Clemson Agricultural College, Clemson, S.C.
Rusoff, L. L., Dairy Dept., Louisiana State University, Baton Rouge, La.
Smith, F. H., Dept. of Animal Industry, University of North Carolina, State College Station, N. C.
Stephenson, Edward L., Dept. of Animal Industry, University of Arkansas, Fayetteville, Arkansas
Summers, John C., Bakery Dept., Oklahoma A & M College, Okmulgee, Okla.
Upp, Charles W., Poultry Industry Dept., Louisiana State University, Baton Rouge, La.
Wallace, H. D., Dept. Animal Husbandry and Nutrition, Florida Agricultural Expt. Station, Gainesville, Florida
Wamble, A. C., Cottonseed Products Research Laboratory, Texas Engineering Experiment Station, College Station, Texas
Watts, A. B., Poultry Industry Dept., Louisiana State University, Baton Rouge, Louisiana

U. S. Department of Agriculture

Ellis, N. R., Bureau of Animal Industry, U.S.D.A., Beltsville, Maryland
Elting, E. C., Associate Chief, Office of Experiment Stations, U.S.D.A., Washington 25, D. C.
Marston, Henry W., Research Coordinator, Agricultural Research Admn., Washington, D. C.
Reed, O. E., Chief, Bureau of Dairy Industry, U.S.D.A., Washington 25, D. C.
Sando, C. E., Bureau of Agricultural and Industrial Chemistry, U.S.D.A., Washington, D. C.
Womack, Madelyn, Biochemist, Food & Nutrition Division, Bureau of Human Nutrition & Home Economics, U.S.D.A., Washington 25, D. C.

Other Federal Agencies

Larsen, Robert A., Chief, Cereal & Baked Products Division, Food Laboratories, QM Food & Container Institute for the Armed Forces, 1819 West Pershing Road, Chicago 9, Illinois
Lightbody, Howard D., Director, Food Laboratories, QM Food & Container Institute for the Armed Forces, 1819 West Pershing Road, Chicago 9, Illinois

******

SUMMARY

(Note: This summary of the conference was furnished on November 9, 1951, to trade and technical journals serving the oilseed industry.)

Feeding tests in which cottonseed meals produced experimentally during the past year by a modified screw-pressing technique developed in cooperative research by the Southern Regional Research Laboratory and the cottonseed crushing industry have borne out earlier indications that processing conditions greatly affect the nutritive value of the meal and can be adjusted to produce meals of superior quality.

Reports of tests in which large quantities of improved cottonseed meals were fed with excellent results to hogs and growing chicks, as well as to other experimental animals, were presented by state feeding specialists from Texas, Arkansas, North and South Carolina, Florida, and Mississippi, and also by members of the U. S. Department of Agriculture, at the second annual conference on cottonseed processing as related to the nutritive value of cottonseed meal, held in the auditorium of the Southern Laboratory in New Orleans November 5-7, 1951. In addition, Mr. Kenneth Kuiken of The Buckeye Cotton Oil Company, Cincinnati, Ohio, described experiments with "degossypolized" cottonseed meal produced by his company.

Attendance at the conference totaled 75 persons from 22 states and Washington, D. C., including, in addition to representatives of the oilseed crushing industry, a number of mixed feed manufacturers, equipment manufacturers, and others from related industries. One company in Denmark was represented. The conference was sponsored jointly by the U. S. Department of Agriculture and the Educational Service of the National Cottonseed Products Association.

Following the reports on feeding, which consumed all of November 5, an entire day was devoted to round-table discussions, in which the results were analyzed and significant questions reviewed in order to pinpoint problems requiring further study. This discussion brought out the need for a standard, uniform ration to be used as a means of minimizing the variables so that more comparable results might be obtained in feeding tests conducted by different research workers. A committee, headed by Dr. J. R. Couch, Department of Biochemistry and Nutrition, Texas Agricultural Experiment Station, College Station, Texas, was appointed to agree upon such a ration in future nutritional studies with cottonseed meal.

Reports by members of the Southern Regional Research Laboratory and by Mr. A. C. Wamble of the Texas Engineering Experiment Station, on Wednesday, brought the group up-to-date on the progress already made in

understanding the fundamentals of cottonseed processing and emphasized the type of additional research needed to develop practical methods of producing the meals of superior nutritive value.

The entire conference pointed up greatly enlarged opportunities for constructive research on cottonseed meal, Mr. A. L. Ward, Director of the Educational Service National Cottonseed Products Association, said in closing the three-day meeting.

"The results of joint efforts of the Southern Regional Research Laboratory, cottonseed crushers, and state and federal experiment stations, reported at this conference are most encouraging and should serve to stimulate continued and enlarged processing and nutritional research with the cottonseed products that are one of the South's most important feeds," he stated. "The large attendance of key representatives from both research organizations and commercial firms is evidence of a growing recognition of the need for, and value of, this research program."

****

RECOMMENDATIONS OF THE STANDARD BASAL RATIONS COMMITTEE FOR COTTONSEED MEAL EXPERIMENTS

A committee composed of J. R. Couch, Chairman, C. L. Morgan, E. L. Stephenson, K. A. Kuiken, N. R. Ellis, H. D. Wallace, F. H. Smith, B. W. Heywang, F. H. Bird, A. B. Watts, and Garlon A. Harper, was appointed by Mr. A. L. Ward, Director of Educational Service, National Cottonseed Products Association, Inc., on November 6, 1951, during the second day of the Second Conference on Cottonseed Processing as Related to the Nutritive Value of the Meal. This committee was appointed for the purpose of formulating Standard Basal Rations for pigs, broilers, and laying hens.

The desirability of appointing such a committee has become apparent due to a lack of uniformity in results from different experimental laboratories where the identical samples of cottonseed meal prepared by the Southern Regional Laboratory were tested. It is believed that the lack of consistency from different laboratories may be eliminated if basal rations, management procedures and experimental methods are standardized in the laboratories of the various workers who are attempting to improve the feeding value of cottonseed meal for farm animals and poultry. Such standardization of rations and methods will include the fact that all workers will use identical samples of soybean oil meal, fish meal, and dried whey in the basal rations.

Directions and instructions prepared by the above committee, along with the Standard Basal Rations, have been mailed from Mr. A. L. Ward's office in Dallas.

****

STANDARD BASAL RATION FOR SWINE

Soybean meal.......................................(See Note 1, below)
(Produced by Central Soya Co., Inc., Decatur, Indiana. Orders should be directed to attention of N. F. Kruse and placed before Feb. 1, 1952)

Ground yellow corn.................................(See Note 1, below)
Limestone or oyster shell.. 1.5 %
Steamed bone meal.. 1.0 %
Lederle Aurofac (1.8 mg B_{12} and 1.8 gms of Aureomycin)........... 0.5 %
Iodized salt mineral mixture (see Note 3, below)................. 0.53%

Notes on formulation and use of Standard Ration:

1. The percentage of soybean meal and ground yellow corn will be adjusted as the protein level of the ration is changed. The ration should contain 20% protein until pigs weigh 75 pounds; use 17% protein, from 75 to 125 pounds; and use 15% protein from 125 pounds to 200 pounds.

2. Experimental cottonseed meals will be substituted for all or 50% of the soybean meal in the comparative test rations.

3. Iodized salt mineral mixture (formulated by H. D. Wallace): 50 lbs. iodized salt; 921 grams $MnSO_4.4H_2O$; 298 grams ferrous sulphate; 125 grams copper sulphate; and 10 grams of cobalt carbonate. After mixing thoroughly, this trace mineral mixture is added at a level of 0.53 pounds per 100 pounds of the ration as indicated in above formula.

4. Add 45 grams (or, 2 pounds per ton) of Lederle Fortafeed 249C per 100 pounds of the ration.

5. Add vitamin A at the level indicated by the National Research Council recommended allowance using high vitamin A potency fish oil (10,000 or 15,000 A) as the source of vitamin A.

6. Add vitamin D_3 at the level indicated by the National Research Council recommended allowance.

7. All tests will be carried out on concrete floors.

8. Weanling pigs weighing approximately 35 pounds will be used in each test.

9. It is recommended that pigs be fed individually. If pigs are lot fed, 5 pigs will be used in duplicate lots on each ration. If facilities are not available for duplicate lot feeding, a minimum of 8 pigs will be group fed on each ration.

STANDARD BASAL RATION FOR BROILERS

Major Ingredients

Soybean meal..(See Note 1, below)
(Produced by Central Soya Co., Inc., Decatur, Indiana. Orders should be directed to attention of N. F. Kruse and placed before Feb. 1, 1952)
Fish meal (60% protein).. 2.0 %
(Produced by Quinn Manhaden Fisheries, Inc., New Orleans, La.; now held in storage at Southern Regional Research Laboratory. Place orders with Dr. A. M. Altschul)
Dried whey product (50% Lactose).................................. 2.0 %
(Produced by Western Condensing Co., Appleton, Wisconsin)
Salt.. 0.5 %
Steamed bone meal... 2.0 %
Limestone... 1.5 %
Ground yellow corn..................................(See Note 1, below)
Lederle Aurofac (1.8 mg. of B_{12} and 1.8 gms. of Aureomycin)................. 0.25% (or 5 lbs. per ton)
Lederle Megasul............................... 0.10% (or 2 lbs. per ton)

Minor Ingredients

$MnSO_4 \cdot 4H_2O$............................... 8 grams per 100 pounds of feed
Riboflavin... 2 mg/lb. of feed
Pantothenic acid................................... 5 mg/lb. of feed
Niacin.. 12 mg/lb. of feed
Choline...200 mg/lb. of feed
Vitamin K (Menadione)............................ 1/2 mg/lb. of feed
(Produced by Merck Company, Rahway, N. J.)
Vitamin A.................................... 2000 I. U./lb. of feed
Vitamin D_3................................. 180 A.O.A.C. /lb. of feed
Feeding grade DL-Methionine.......................... 1 lb. per ton of feed

Notes on Use of Standard Ration

1. One group of each experiment is to receive the above listed ration as a standard check control. The protein content of the ration (check or experimental) should be 21.5% protein, maintained by adjustment of amounts of corn and soybean meal (or cottonseed Meal) according to the protein content of the feedstuffs.

2. Each sample of cottonseed meal to be tested in these studies will be used to replace all of the soybean meal in one lot and will replace one-half of the soybean meal in another lot.

3. New Hampshire chicks of either Nichol or the Christie strain will be used.

4. A minimum of 20 chicks per lot will be used and each lot will be run in duplicate. (Total - 40 chicks per treatment).

5. Duration of all experiments will be 10 weeks.

6. The vitamin K (2-methyl-1, 4-Naphthoquinone) should be dissolved in ethyl alcohol (50 milligrams in 250 milliters) prior to mixing.

STANDARD BASAL RATION FOR LAYING HENS (ALL-MASH)

Major Ingredients

Soybean meal..(See Note 1, below)
(Produced by Central Soya Co., Inc., Decatur, Indiana. Orders should be directed to attention of N. F. Kruse and placed before Feb. 1, 1952)
Ground yellow corn..................................(See Note 1, below)
Dehydrated alfalfa leaf meal (17% protein)...................... 3.0 %
Steamed bone meal... 2.0 %
Limestone or oyster shell....................................... 1.5 %
Salt.. 0.5 %
Lederle Aurofac (1.8 mg. of B_{12} and 1.8 grams of Aureomycin)................. 0.25% (or 5 lbs. per ton)

Minor Ingredients

$MnSO_4 \cdot 4H_2O$.............................. 8 grams per 100 pounds of feed
Riboflavin.. 2 mg/lb. of feed
Pantothenic acid.................................... 5 mg/lb. of feed
Niacin.. 12 mg/lb. of feed
Choline... 200 mg/lb. of feed
Vitamin K (Menadione)............................... 1/2 mg/lb. of feed
(Produced by Merck Company, Rahway, N. J.)
Vitamin A... 3300 I. U./lb.of feed
Vitamin D_3.................................. 450 A. O. A. C./lb.of feed

Notes

1. One group of each experiment is to receive the above listed ration as a standard check control. The protein content of the ration (check or experimental) should be 16.5% protein, maintained by adjustment of amounts of corn and soybean meal (or cottonseed meal) according to the protein content of the feedstuffs.

2. Hen size oyster shell will be kept before the hens at all times.

3. The vitamin K (2-methyl-1, 4-Naphthoquinone) should be dissolved in ethyl alcohol (50 milligrams in 250 milliliters) prior to mixing.

****

Table 1. Analyses of Experimental Cottonseed Meals, Series 5-13

Meals	Type	% H_2O	Gossypol Free	Gossypol Total	Nitrogen Soluble	Nitrogen Total	% Oil	Thiamine p.p.m.	Max. Cooking Temperature
Series 5 No. 1	Screw Press	6.54	0.028	0.66	15.3	7.08	3.70	7.84	230° F.
No. 4	Screw Press	7.34	0.026	0.66	16.9	7.33	3.80	9.12	230° F.
No. 9	Screw Press	6.37	0.019	0.51	31.7	6.84	4.1	13.0	180° F.
Mixture 9 and 10	Screw Press	6.5	0.03	0.60	36	6.7	4.1	14.0	180° F.
Series 5 No. 10	Screw Press	6.26	0.044	0.61	41.4	6.53	4.1	15.1	180° F.
No. 12	Screw Press	6.69	0.034	0.52	23.0	6.70	4.11	12.68	180° F.
No. 13	Screw Press	5.90	0.028	0.59	26.5	6.48	4.05	12.27	200° F.
No. 14	Screw Press	6.25	0.046	0.56	42.2	6.55	4.70	13.23	200° F.
No. S514 (mixture of 5 & 14)	Screw Press	6.34	0.041	0.309	40.0	6.01	4.63	13.3	200° F.
No. 16	Screw Press	6.57	0.020	0.56	35.0	6.45	3.78	11.52	160° F.
Series 6 No. 3	Screw Press	7.35	0.021	0.64	9.2	6.72	4.01	4.39	
No. 10	Butanone extracted	7.69	0.012	0.12	70.7	9.10	0.18	29.9	
No. 12	Isobutane extracted	8.76	0.34	0.72	66.05	6.78	3.60	18.1	
No. 28	Butanone extracted		0.013	0.019					
No. 42	Hexane extracted	12.69	0.28	0.26	63.4	6.83	1.33	24.24	
No. 61	Hydraulic	11.96	0.022	0.78	17.2	6.37	5.71	11.41	
No. 62	Butanone extracted		0.010	0.133					
No. 71	Screw Press	5.65	0.028	0.83	11.9	6.94	3.68	7.57	
No. 76	Butanone extracted	7.03	0.021	0.14	65		0.15	9.32	
No. 79	Hydraulic		0.053	1.06	22.3	7.02			
Series 7 No. 304	Hydraulic	8.8	0.03	1.04	34.0	6.8	4.8	8.6	
Series 8 No. 1	Screw Press	2.53	0.026	0.37	15.92	7.38	5.05	7.52	229° F.
No. 3	Screw Press	4.83	0.028	0.87	41.06	7.11	4.84	18.36	174 F.
HS 12 T-1	Screw Press	4.68	0.03	0.80	23.3	7.23	3.89	11.05	240° F.
T-2	Screw Press	6.58	0.05	0.63	55.2	6.59	5.21	16.14	160° F.
T-3	Screw Press	6.58	0.03	0.62	53.6	6.47	5.03	15.55	180° F.
T-4	Screw Press	5.35	0.03	0.65	40.7	6.48	4.40	14.04	200° F.
ES 13 T-1	Screw Press	6.00	0.055	1.09	12.8		4.54	5.49	240° F.
T-4	Screw Press	5.51	0.042	1.18	19.0		4.83	9.82	200° F.
26576	Gland free	8.16	0.06		85.3	10.1	1.5	39.5	
St. Soybean		11.54			24.3	8.09	0.86	10.36	

Table 2. Distribution of Experimental Cottonseed Meals, Series 5-13

Meals		Investigators Using Meal *										
Series 5	No. 1				D							K
	No. 4								H			
	No. 9				D				H			
Mixture 9 and 10									H			
Series 5	No. 10				D				H			
	No. 12 1/					E						
	No. 13	A		C	D							
	No. 14		B									
	No. 16	A			D							
Series 6	No. 3	A										
	No. 10	A			D							
	No. 12	A										
	No. 28 2/					E						
	No. 42 1/					E						
	No. 61		B		D							K
	No. 62											K
	No. 71		B									
	No. 76		B		D							
	No. 79								H			
Series 7	No. 304				D							
Series 8	No. 1		B				F					K
	No. 3		B				F					K
HS 12	T-1		B	C	D			G			J	K
	T-2				D							
	T-3		B		D			G			J	K
	T-4			C							J	K
ES 13	T-1											
	T-4							G		I		K
26576		A										
St. Soybean		A		C	D				H	I		J

* F. H. Bird..............A
J. R. Couch..............B
T. J. Cunha..............C
H. D. Wallace............C
N. R. Ellis..............D
B. W. Heywang............E
D. A. King...............F
C. M. Lyman..............G
C. L. Morgan.............H
F. H. Smith..............I
E. L. Stephenson.........J
M. Womack................K

1/ Different mixtures of these meals were used to give products having free gossypol contents from 0.023 to 0.21%.
2/ Mixed with gland-rich meal to give meals with free gossypol contents from 0.013 to 0.040%.

Table 3. Description of Cottonseed Meals in Nutrition Processing Test, Series 1.

Meal No.	Water added to cooker: lb/hr 5/	Temp. of meats: °F.	Time of cooking: min.	Meal: Lipids: % 6/	Meal: Free gossypol: % 6/	Meal: Moisture: % 6/	Meal: Total nitrogen: % 6/	Meal: Soluble 7/ nitrogen: % of total
			Hydraulic-pressed Meals 1/					
2	70	118-230	36	5.6	0.108	7.6	6.4	39.2
9	90	118-240	72	5.6	0.047	5.6	6.4	20.8
			Screw-pressed Meal 2/					
7 4/	None	100-200	70	3.4	0.008	4.7	6.4	12.8
8 4/	None	110-178	15-20	3.3	0.011	4.6	6.9	14.3
6 4/	None	100-200	15-20	3.4	0.009	4.1	6.5	15.9
1	None	113-234	15-20	3.5	0.014	4.6	6.9	11.7
3	None	126-261	20	3.6	0.016	4.4	7.0	10.0
4 3/	60	202-262	40	3.8	0.022	4.5	7.0	10.3
5 3/	70	222-278	100	5.7	0.030	3.7	6.6	8.2

1/ From rolled meats: water added before rolls for hydraulic runs was 60 lb./hr.

2/ From disc hulled meats.

3/ Four rings of cooker used. In all other runs involving screw press, only three rings were heated.

4/ In order to obtain these low temperatures, doors of cooker rings were kept open.

5/ Meal production on the screw press was at the rate of 600 lb./hr.

6/ On as received basis.

7/ Determined in 0.5 N NaCl solution at a solvent-meal ratio of 40:1.